The Mysore Agricultural Journal

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IN THIS ISSUE

BLAST DISEASE OF RICE

GROUNDNUTS IN MYSORE

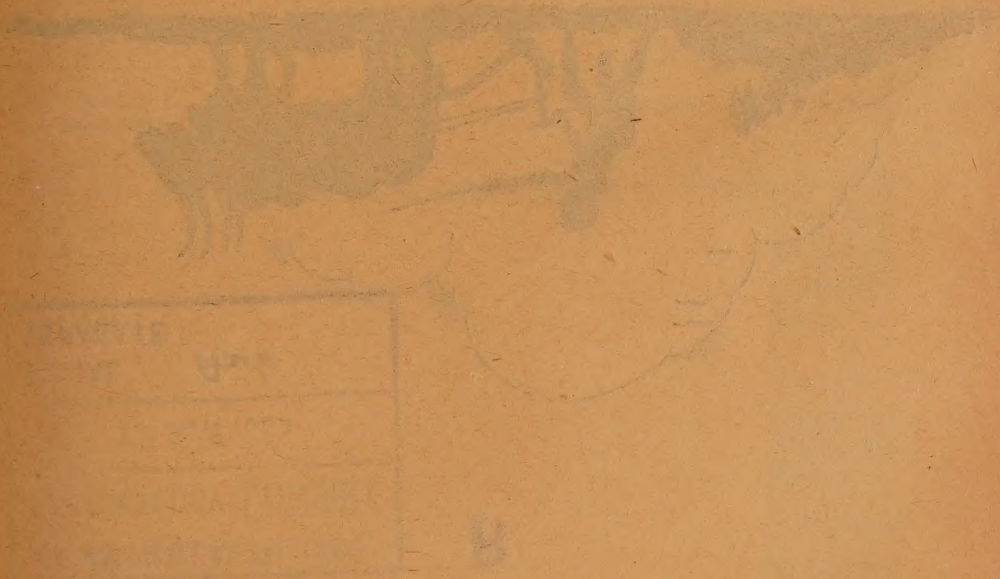
MYSORE DACINÆ AND THEIR NATURAL PARASITES

CULTIVATION OF GARLIC IN MYSORE

EFFECT OF LIME AND PHOSPHATE ON GROUNDNUT POD FILLING

TWO DISTINCT SPECIES OF EPILACHNA BEETLE

PROSOPIS JULIFLORA AS A LIVE FENCE



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CONTENTS

PAGE

Rafi Ahmed Kidwai—Obituary—BY M. L. N. IYENGAR .. 209

EDITORIAL

Sri. B. Krishna Murthi 212

EDITORIAL ARTICLE

Mesquites : Are They Desirable for Mysore ?—BY M. L. N. IYENGAR 214

ORIGINAL ARTICLES

Blast Disease of Rice, Oryza sativa *L.,* Piricularia oryzæ *Bri.* et *Cav.* [P. grisea (*Cooke*) *Sacc.*]—By Dr. M. Puttarudriah 221

Groundnut in Mysore—By K. Gopala Iyengar 252

Mysore Dacinæ and Their Natural Parasites—By Dr. M. Puttarudriah and S. Usman 257

Cultivation of Garlic in Mysore—By R. S. Ayyangar .. 263

Effect of Lime and Phosphate on Yield and Pod Filling of Groundnuts—By B. V. Venkata Rao and Dr. S. V. Govindarajan 277

Two Distinct Species of Epilachna (*Coleoptera : Coccinellidæ*) *Feeding on Solanaceous and Cucurbitaceous Plants*—By G. P. Channa Basavanna 280

Prosopis juliflora *as Live Fence*—By K. Venkoba Rao .. 286

Secretary's Page 289

CORRESPONDENCE

Use of Well Balanced Mixed Fertiliser for Potato Crop—By B. Channa Byre Gowda 293

Observations on the Duration of Time Taken by Crop Plants from Flowering to Maturity—By D. Venkataramaniah 294

My Impressions of Mysore—By Monte W. Alderfer .. 295

RAFI AHMED KIDWAI

THE sudden death of Sri. Rafi Ahmed Kidwai, Union Minister for Food and Agriculture, on the evening of 24th October 1954, has removed from our midst, perhaps the most colourful personality in India. There was a feeling of profound and sincere shock and a spontaneous outburst of grief throughout the country when the news came through the All-India Radio.

Sri. Kidwai was a great national hero and organiser in the struggle for Indian Independence, an ardent patriot, an outstanding statesman and a most able and successful administrator.

Great as he was as a patriot and administrator, he was greater still as a man. In him were uniquely synthesised sacrifice and ability, clearsightedness and boldness, realistic outlook and originality of approach, acumen and drive, intellect and action.

Born in 1894, he gave up his studies during the Non-Co-operation Movement and became Secretary to Pandit Motilal Nehru, father of our Prime Minister. He was elected to the Central Assembly in 1926 and became the Chief Whip of his Party. He was the Revenue Minister in his home State of U.P. for a number of years. He was arrested several times and spent more than 10 years in prison. He joined the Union Cabinet in 1947 and after a most successful term as Communications Minister he became Minister for Food and Agriculture in 1952. Rafi Saheb's achievements and stock stood so high that there was no doubt he would repeat his great success even in this Ministry which is regarded as the graveyard of mighty reputations.

The earlier experiment in Food Decontrol initiated at the instance of Gandhiji in 1947 had proved disastrous. The country had lost faith and confidence in its own strength and capacity to "manage its larder without the help of controls". But Sri. Kidwai was not accustomed to accept defeat in any job he undertook. He toured the country and studied the conditions in the countryside himself. He was always

unerring in his estimates and assessments of situations and his intimate contacts with the rural folk had convinced him that with some luck, the battle for food-sufficiency could be won. By the middle of 1953 sufficient stocks of wheat had accumulated in the country. The United States Wheat Loan was of great help. The two previous monsoons had been favourable and Sri. Kidwai thought that the stage was set for the final victory. He started preparing the country for the great event. Rafi Saheb spoke little, but whenever he did, he had always something new, something surprising and something unorthodox to tell. In a speech in Bombay he declared in measured tones, "For all practical purposes, the food problem has ended". These words were unbelievable, but they had an authentic ring about them. They were said with confidence born of deep study and appraisal and more than all they were uttered by Rafi Ahmed Kidwai. The people rubbed their eyes and were prepared to shake their heads like old jeremiahs. But they remembered Rafi Saheb's grand achievements and were ready to believe that he could work miracles. They had by then learnt that Sri. Kidwai either did things or got them done. When he further added in the course of his speech that the Government had such large stocks of wheat that they did not know what to do with them he sounded almost impossible and incredible. A discreet warning was thus administered to the hoarders and a wave of confidence passed over the country. The vicious circle was broken and the spell of controls paled. Other measures were put through in quick succession to back up his words and by the beginning of this year control over all grams and grains were removed. In July of this year was achieved the most important and final victory in the food front. The most intractable food problem of all was solved and rice was decontrolled.

To celebrate this great victory, his innumerable friends and colleagues got up a party in Delhi a few weeks before his death. Kidwai was nowhere to be found at the appointed time and a hectic search was initiated. To the surprise of all he had by then slipped into the party unnoticed and occupied one of the small tables and no persuasion proved of any avail to bring him to the chief guest's table. This

illustrates the most unique quality of Kidwai, namely, self-effacement.

Some people think that Kidwai was very lucky. The secret of his luck was his sturdy commensense, his amazing capacity for very hard and sustained work, his uncanny judgment, his sound grasp of any subject he proposed to handle, his correct and almost instinctive appraisal of the import of any situation, his surprisingly quick decisions and his firm action. In the words of Sri. C. Rajagopalachari, easily the brainiest of Indian Statesmen, "no one had a more alert brain, or quicker grasp or shrewder commonsense in the difficult problems that arose in the portfolio of food during the last few years".

Sri. Rafi Ahmed Kidwai was the right-hand man of our Prime Minister with whom he worked in the closest of associations for over 35 years. His loss to Pandit Nehru was one "he could hardly bear". To his large body of friends and co-workers, he was a great captain and an elder brother to whom they instinctively turned in the solution of any intricate problem. He was indispensable both during the years of struggle for independence and in subsequent years of building a new India. He used every little ounce of energy, strength and vigour in the service of the country, disregarding his doctors' advice and neglectful of his health. His was a completely dedicated life.

Kidwai was not merely a unique personality but a great institution. In the words of the Government of India, he was "a true representative of the broad humanitarian culture which has been evolved in India through the contributions of peoples of many races, many religions and many traditions. He had a profound faith in the future of the nation. A combination of exceptional qualities of intellect, emotion and imagination made him truly a leader of men whom his grateful countrymen will not easily forget".

He will soon pass into legend and his name will become "synonymous with all that is efficient and successful in the conduct of the country's affairs". Kidwai is dead but Kidwaiism will remain immortal.

M. L. N. Iyengar.

Editorial

SRI. B. KRISHNA MURTHI, B.Sc., F.R.E.S.

Sri. B. Krishna Murthi, Government Entomologist, retired on 19-5-1954 after a long, fruitful and distinguished service of thirty-three years.

Born in 1899, he was educated in that great institution—the Central College, which has given the State a succession of brilliant scientists, administrators and public men. Soon thereafter, at the early age of 21, he joined the Mysore State Department of Agriculture as a Junior Assistant in the Division of Entomology, headed by Dr. K. Kunhi Kannan and guided by Dr. L. C. Coleman. To make a mark in such a *milieu* of brilliance was indeed very difficult, but to Sri. Krishna Murthi, with his zeal and capacity for sincere work, it was not. Studious, methodical and reserved, he devoted himself entirely to his work, unmindful of official disappointments and monetary returns for his labours. He soon earned a name for himself both in fundamental and applied entomological research, among which may be mentioned his studies and investigations on the suctorial apparatus of cicadas, origin and elimination of opaque globules in aphids, microscopic study of the development of *Trichogramma minutum,* taxonomy of Mysore aphids, epilachna beetle of potato, etc.

After nearly two decades of hard work, he succeeded Sri. T. V. Subramaniam as Government Entomologist in 1942. He continued and extended the scope of the excellent programmes that his predecessors in the office had persued with vigour and success. Within a short period of twelve years as its chief, he developed the Division of Entomology into one of the foremost agricultural entomological research teams in India. Side by side with guidance and direction of fundamental research, he devoted considerable time and energy to the prevention and control of crop pests. With the encouragement of the then Director of Agriculture, Sri. K. H. Srinivasan, he organised a Plant Protection Service—one of the earliest in India. He also took up large-scale control measures against serious crop pests like *jola* grasshopper, sugarcane top shoot

SRI. B. KRISHNA MURTHI, B.Sc., F.R.E.S.

Government Entomologist (1942–54)

[*Photo by P. R. Raghuram*

borer, cardamom hairy caterpillar, *jola* and ragi earhead pests and the blue beetle of paddy, etc.

He also initiated biological studies of the stem-borers of tobacco, coffee, paddy and ragi. Not content with such pioneering work, he wrote the first book in Kannada on Insects.

He had a deep insight into the problems of agricultural entomology and plant protection and was a lucid exponent of the subject. His lectures in the Mysore Agricultural School and Mysore Agricultural College were listened to with rapt attention and great interest.

He was a very successful teacher, a distinguished scientist, a very efficient administrator and a great captain of his team. He had won the loyalty and devotion of all his men—from the lowest to the highest. He gave them a free hand but silently and effortlessly he guided and moulded their work and ideas, encouraged them to think and launch out on new lines, fought for them whenever necessary and helped them wherever possible. He did all this without raising his voice or crowing about his benefactions or showing off his goodness and greatness. In fact he hated every kind of effusiveness, demonstrativeness and theatricality. This was reflected even in his dress. Barring only one, he was the best dressed man in the Department. Sombre and harmonious in colour, well cut, well preserved and immaculate, the clothes fitted the gentleman and his character. He disliked slovenliness of any kind, in dress, thought or work. He was friendly without being familiar, reserved without being boorish, polite and courteous without sarcasm, exacting without harassing, sympathetic and affectionate to his colleagues and students (among whom the present writer was fortunate to be one) without being demonstrative, his words matched his actions. Whatever he said, he meant and whatever he meant, he did.

He has left behind him a great tradition of amity, hard and sincere and pioneering work which his successor Dr. M. Puttarudriah is anxious and striving to preserve and maintain.

The Mysore Agricultural and Experimental Union and the Mysore State Department of Agriculture salute him and wish him all happiness during his well earned rest.

Editorial Article

MESQUITES: ARE THEY DESIRABLE FOR MYSORE?

By M. L. N. Iyengar*

Mesquites have been introduced into various parts of the world as useful fodder trees. They have many virtues and a few outstanding vices. Later in this number we have published an article on the use of mesquites as 'live' fence on the banks of the Hagari River in Bellary District. In this note, we discuss their other merits and demerits to enable our farmers and foresters to determine their usefulness or otherwise in Mysore.

Two species of mesquites, *Prosopis glandulosa* and *P. juliflora* were introduced into Mysore several decades ago, in any case earlier to 1894. They were reintroduced from Saharanpur in 1913 and 1915. *P. juliflora* was again introduced into the State by the late Dr. K. Kunhi Kannan* who brought a few seeds from Hawaii and raised them at Hebbal Farm in 1922. The plant, however, has not made much headway in Mysore. Of the 300 seedlings planted at Hebbal less than half-a-dozen have survived now. In the Punjab, at any rate, they are reported to prosper very well and are being recommended for grazing lands, bunds, field boundaries, burrow pits of village roads, tank and well borders, village groves and public building compounds. They are so popular in this part of the sub-continent that thousands of seeds have been distributed from the Hissar Cattle Farm. The tree has become common in the Punjab.

The mesquites belong to the genus *Prosopis* (Fam. *Leguminosæ*) containing more than 20 species and a good number of minor forms. Two species are represented in India, one of which, *P. spicigera* (ಪುನ್ನೆ) is also found in Mysore. Argentina is considered as a centre of plymorphism of this genus with nearly 20 good species and quite a large number of forms. One species *P. ruscifolia* in the Chaco Plains has large leaflets and yields an antibiotic—the alkaloid vinalin. There are two species which have dry and grass-like leaves, *P. alpacato* and *P. argentina.* But the most important species of this genus are (1) *P. chilensis* or Algaroba, (2) *P. juliflora* or the common mesquite, (3) *P. glan-*

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* Entomologist to the Govt. of Mysore, 1923-31.

dulosa or the honey mesquite, and (4) *P. velutina,* the velvet mesquite. The nomenclature of the various species of this genus appears to be confused ; the same species is called by different names by different authors. For example, the species which Father Bachelot introduced into Hawaii in 1928 is described by some authors as *P. juliflora* and by others as *P. chilensis.* But whatever the scientific name, the mesquites have many important common features and properties and in this note they will be treated as a group. They are genrally shrubs or trees, very resistant to drought and adapted to a variety of climates—temperate, tropical and sub-tropical, arid and sub-arid, and of soils—light or shallow.

P. chilensis or algaroba bean which was so called on account of its superficial resemblance to the carob tree of Hawaii is a native of Chile, Argentine and Peru. It is a browse plant of the southwestern United States and of West Indies. It has become naturalised in Hawaii where, according to Rock, "no tree so far introduced has proven of such enormous benefit as the algaroba. All waste lands in these islands, which previously to the introduction of this valuable tree were absolutely barren, are now covered with green forests made up exclusively of this tree". Dr. Kunhi Kannan who had opportunities of observing the habits of the tree in Hawaii, reported as early as 1923 that the algaroba had, since its introduction spread to 100,000 acres. The tree is confined to the leeward portions of the island, where the rainfall is scanty and in places so scanty that they may be little different from semi-arid desert. The tree is rarely found on the windward side of the islands where the rainfall varies from 200 to 400". This indicates that algaroba may suit the dry parts of the Mysore Plateau like Kolar, Tumkur, Chitaldrug and Bellary and may be unsuitable for the *malnad.* The algaroba is said to be popular in Indonesia and S. Africa where it is considered as a famine fodder in the *karoo* (desert shrub land).

P. juliflora is typical of Jamaica. *P. glandulosa,* considered by some as a variety of *P. juliflora,* and *P. velutina* are from Mexico.

Although the mesquites are of South and Central Amerian origin, they have been thriving well in U.S.A., Sudan, India, Australia, Philippines, etc. In most countries it is regarded as a valuable introduction but in a few, like the south-western parts of United States, it is regarded as a pest overrunning millions of acres and the invasion of which into grazing lands, especially

in Texas, has been so extensive and has occupied so rapidly that it is being compared to the inroads of the boll weevil into the cotton belt.

Uses

Leaves.—The uses of mesquite are various. In Brazil, Chile, Mexico and Guatemala, the leaves are regarded as excellent fodder although the plants are mainly preferred for the fruits. In some parts of Central Mexico, during the dry season, the cattle get their entire nourishment from mesquites and similar plants. In the Punjab, however, it is stated that the leaves are not relished by stock and this is regarded as an advantage for it saves the new plantations from extermination. Unfortunately, the leaves are not disliked by the ubiquitous goat and therefore it may turn out to be not an advantage after all. Cattle may, to some extent, be trained to accept strange fodders. Like men, tastes for exotic foods can be cultivated by domestic animals and attempts should be made to accustom cattle to mesquite leaves gradually. In the south-western states of U.S.A. the leaves are sometimes grazed sparingly, especially in the spring and as an emergency forage. While this is the case in a country where rich pastures are available, it should be possible in our country to utilise the leaves to a greater extent. The chemical composition of the leaves and other parts of the two species of *Prosopis* is given in the following table.

Table

The Chemical composition of the leaves and other parts of two species of Prosopis

	Protein	Ether Extract	Crude Fibre	N-free extract	Ash	Calcium	Magnesium	Potassium	Phosphorus
Prosopis chilensis—									
Pods ..	13·7	1·9	27·9	52·6	3·9	0·65	0·11	1·42	0·20
Bean meal dried ..	9·5	1·5	23·2	57·9	4·3	..	..	..	..
Foliage young ..	23·5	2·9	24·7	44·2	4·7	0·88	0·21	1·35	0·25
Do middle ..	21·2	3·2	28·5	41·8	5·4	1·91	0·21	1·48	0·16
Do mature ..	18·9	4·2	37·3	41·5	8·2	3·04	0·30	1·32	0·19
Prosopis juliflora—									
Whole fruit ..	13·0	2·5	27·4	52·5	4·6				
Fruit pericarp ..	6·7	1·0	31·3	56·5	4·5				
Seeds ..	36·3	4·9	56·5	47·2	4·7				
Seed kernels ..	65·2	7·8	2·8	19·1	5·2				
Leaves ..	19·0	2·9	21·6	47·9	8·5				
Flowers ..	21·0	3·2	15·5	50·3	10·0				

Few fodder plants are as rich in protein content of leaves as the *Prosopis* species. They are excelled by only a few *acacias* (ಜಾಲಿ), bamboos, *Ficus religiosa* (ಅರಳಿ), [young leaves], *Moringa oleifera* (ನುಗ್ಗೆ), *Pithecolobium dulce* (ಸೀಮೆಹುಣಿಸೆ), *Sesbania grandiflora* (ಅಗಸೆ) and a few others in India and *Caroxylon salsola* (S. Africa), *Alysicarpus rugosus* (Queensland), etc., outside India.

Fruits.—It is the fruits of mesquites that are preferred all over the world for their nutritious pulp. In Chile, they are collected and sold as fodder for all kinds of stock including mules and horses, draught oxen, fattening cattle, some types of dairy cow, sheep, swine, etc. These animals are fond of the pods and seek them.

The exceptionally nutritious and highly palatable pods are 4-8" long and are borne in clusters near the tips of branches. They have a thick, spongy pericarp full of sugary pulp, and contain 62·7 per cent. fermentable sugar. 74 per cent. of the fruit is pulp and the rest seed and capsule. In addition to sugar, the pulp contains 11·4 per cent. protein, 4·26 per cent. fat, 8·18 per cent. starch and 4·4 per cent. cellulose.

The fruit of the mesquite consists of two types of food material: (1) that in the pericarp or pod including the outer covering (epicarp), the sugary pulp (the mesocarp) and the seed capsules or husks (the endocarp); the nutrients of this pericarp are wholly available to the animals and contain nearly all the sugar, and most of the crude fibre and tannins; (2) that in the seeds containing most of the protein and fat. These seeds pass through the digestive tract of the animals eating the pods practically unchanged. By grinding the entire mature fruit, the nutrients in both the portions of the fruit may become available. But this is not easy as the large quantities of sugar in the pulp clog the grinding mill.

So, for the complete utilisation of the fruit, it has to be separated into (1) sugary pod and seed-husk, and (2) high protein seed meal. By keeping the fruit 'bone dry' it has been demonstrated on a laboratory scale that it is practicable to obtain, by milling the entire pod, a material containing 94 per cent. of the sugar originally present and the whole of the seeds. The seeds can then be moistened and milled. This kernel meal contains over 60 per cent. of crude protein. It is therefore one of the richest natural protein concentrates in the vegetable kingdom slightly surpassing the oil-free kernels of cotton seeds and

peanuts. But it must be remembered that these results were obtained only from laboratory experiments. If the fruit is thoroughly dried at low heat and the first stage of milling is conducted in a dry atmosphere it may be possible to obtain the results on a larger scale but this has to be investigated further.

The seed-coat material contains over 14 per cent. of pentosans, 20 per cent. galactans and nearly 35 per cent. of other readily hydrolyzable carbohydrates.

It has also been reported that sucrose has been prepared from the pods as they are rich in non-reducing sugar. It must be stated here that while the fruit of the mesquite is a valuable feeding stuff when sound, it may be harmful to stock if it has been subjected to soaking. Dr. K. C. Sen (*Animal Nutrition Research in India*) lists *Prosopis juliflora* as a poisonous plant, particularly for goats. In Hawaii, where the mesquite has been recognised as one of the most important feeds of the island, it is reported that a slight flavour is imparted to the milk when beans are fed in excess to a dairy cow. But this can be overcome by feeding the beans after milking rather than before.

A medium-sized tree with a spread of not more than 14-18' bears in South New Mexico 1-1½ bushels (21-31½ lb.). In North-Western Frontier Province, a tree may yield more than 200 lb. of pods per year. Dr. Kunhi Kannan put the yields between 200-300 lb. The yield varies with the type and size of bush or tree. An acre of trees may yield 100 bushels or about 2,100 lb. per year. In Arizona and Texas, two crops per year are obtained. In the plains of the Punjab also, the tree yields two crops per year.

In addition to being a rich stock feed, the pods are a staple food of Red Indians and Mexicans. Dr. Kunhi Kannan reported that children in Texas eat the yellow ripe pods that drop to the ground. In Oahu island in Hawaii, he reported that 25,000 tons were produced annually and that a factory was established to process this produce. A popular beverage is prepared from cooked and strained beans. A worker may gather about 175 lb. per day.

Mesquite as a Source of Honey.—The honey mesquite—*P. glandulosa* is a very famous honey plant ; its nectar is supposed to make a very high grade honey. In many parts of the world as in Hawaii and Texas this is the main source of honey for the large number of bee hives kept there. The tree has long

flower spikes yielding large quantities of pollen and honey. Dr. Kunhi Kannan stated that 200 out of the 600 tons of honey produced in Hawaii, when he was there, was derived from mesquite. He estimated that a tree with 30′ spread produces about 2½ lb. of honey. Its introduction to the arid plains in our State where there is a scarcity of bee flora may prove worthwhile. One advantage this tree has over many others is that it produces flowers twice a year in many regions, the flowering period lasting for nearly 4-5 months in each season. Thus, for practically 10 months in the year the mesquites will be in flowers, ensuring a continuous supply of honey for the bees. On account of a very efficient and extensive root system, mesquites produce flowers even in a dry season provided there have been good rains in the later part of the previous season or year.

Ornamental Uses.—The flowers in long spikes of 4-6″ have a sweet scent. The tree is very graceful and may prove useful in public gardens and parks. In favourable regions as in Tuscan in Arizona, the tree is reputed to attain a height of even 65′.

Wood.—The wood from mesquite makes good fuel. As there is little sapwood, excellent charcoal can be made from the root wood. The wood also takes very good polish and is therefore employed for furniture and cabinet work. The stout branches make excellent fence posts. It also yields a gum which is similar to gum arabic.

Erosion Control.—The mesquites have a remarkable root system which binds the soil and prevents erosion. On bare village fields and scantily grassed *gomals* as well in sandy soils, mesquites hold the soil against erosion both by wind and water.

Other Uses.—The mesquite is a useful shade tree and makes a good windbreak. It can also be used as live fence. The seasonal fall of the leaves enriches the organic matter content of the soil.

Disadvantages

These, then, are the virtues of this remarkable group of plants. These trees and shrubs have a surprisingly well developed root system. In at least two species—*P. juliflora* and *P. glandulosa* this root development is said to exceed that of any other observed plant species. The vertical penetration of roots into the ground reaches in many instances 30′ and on occa-

sions it may well reach even 60' below the ground surface. Its lateral spread will be up to 75' or even more.

It is this agressiveness and capacity to draw soil moisture from an extensive zone that has made it such a desirable tree for arid and sub-arid regions. But unfortunately, it is precisely this agressiveness that has also made it such a pest in the south-western States of U.S.A. where it has invaded into rich grass land.

Is the mesquite, then, a desirable plant for the Mysore plateau ? So far it has not exhibited any such aggressiveness here. Although introduced over 60 years ago, the natural spread of this group of plants has been negligible and even where deliberately planted it has not established very well. In the light of its very desirable virtues and lack of aggressiveness in Mysore we should explore the possibilities of raising them in the form of small plantations in the arid tracts of Mysore, in village waste lands and *gomals* and in the scrub jungles. It would be highly desirable if the Forest Department and the Gardens Department examine this subject in greater detail.

References

Anon (1947), "The Use and Misuse of Shrubs and Trees as Fodder", *Imp. Agric. Bur. Jt. Pub.*, 10.

Cameron, J., Ed. (1894), *The Forest Trees of Mysore and Coorg*, Bangalore.

Dayton, W. A. (1931), "Important Western Browse Plants", *U.S.D.A. Misc. Pub.*, 101, 73-77.

Krumbiegel, G. H. (1948), *List of Economic Plants Imported in Lalbagh Botanic Garden*, Bangalore, 72.

Kunhi Kannan, K. (1923), *Agric. J. India*, 18, 2.

——— (1923), *J. Mysore Agric. Expt. Union*, 5 (2), 108-10.

Nambiar, K. K. (1944), "Improving Germination of *Prosopis juliflora*", *Madras Agric. J.*, 32, 203-06.

Parker, K. W. (1943), "Control of Mesquite in S. W. Ranges", *U.S.D.A. Leaflet No.* 234, 8.

Walton, G. P. (1923), "Chemical and Structural Study of Mesquite, Carob and Honey Locust", *U.S.D.A. Dept. Bull. No.* 1194, 1-15.

Whyte, *et al.* (1953), "Legumes in Agriculture", *F.A.O. Agricultural Studies*, 21, 316-17.

BLAST DISEASE RICE, *ORYZA SATIVA* L. *PIRICULARIA ORYZÆ* BRI. *ET* CAV. [*P. GRISEA* (COOKE) SACC.]

PREFACE

BLAST DISEASE of rice is a major disease in India and many other countries, wherever rice is grown. The information collected here was taken from many sources, to form the term paper which had to be submitted to the Division of Plant Pathology, University of California, Berkeley. It was thought that this information about this important disease of rice would be of some value to the workers in this field of study, and so, the authorities of the *Mysore Agricultural Journal* have decided to publish it in their Journal, for which I am thankful to them.

I am also grateful to the Government of Mysore for enabling me to stay from 1948 to 1950 at the University of California, Berkeley, being deputed for higher studies in Entomology. The study of rice blast disease was part of plant pathology course which was one of the allied fields of my study.

M. PUTTARUDRIAH

CONTENTS

(Adopted from Whetzel)

	Page
Introduction	223
Host Range	223
Species Affected	
Varietal Susceptibility	
Name, History and Range of Disease	225
Importance	229
Nature of Losses	
Amount of Losses	
Other Aspects	
Symptomatology	230
Morphologic Symptoms	
Histologic Symptoms	
Morphologic Signs	
Histologic Signs	
Etiology	233
Morphology of Pathogen	
Name, History and Classification	
Pathogenicity	
Variability	
Life-History	238
Primary Cycles	
Pathogenesis	
Inoculation	
Incubation	
Infection	
Saprogenesis	
Secondary Cycles	
Epiphytology	241
Control	242
Exclusion	
Eradication	
Protection	
Immunization	
Therapy	
Summary	246
Acknowledgements	247
References	247

BLAST DISEASE OF RICE, *ORYZA SATIVA* L. *PIRICULARIA ORYZÆ* BRI. *ET* CAV. [*P. GRISEA* (COOKE) SACC.]

Introduction

Rice is one of the major and important food crops of India, Burma, Japan, China in the continent of Asia ; and also grown over a large area in Europe, America, Africa and Australia. Saha[38] has stated that India is the biggest producer, the annual output being about 35,000,000 tons ; China and Japan coming second and third ; then the other countries. This important crop is subject to many diseases and insect pests. Of the many fungus diseases, blast is one of the serious diseases on rice, which sometimes takes away a heavy toll of the crop. It is quite necessary to have a thorough knowledge of the causal organism, its infection and control measures to protect this important crop against the outbreak of the blast. A great deal of work has been done on this pathogen in Japan, Italy, India and many other countries ; but the information is scattered in so many journals that it is impossible to get ready information about this disease. So it is the object of this paper to present as much of information as possible on all aspects of this disease, in a sequence, so that it will be useful to the cultivator to get information for control measures ; and the investigator to know the position of the disease and adjust his investigations accordingly. Most of the information has been compiled with reference to the reviews of many papers by various authors, published in *Review of Applied Mycology* volumes from 1922 up to 1948 , *Biological Abstracts* and *Experiment Station Records* (some volumes), and some reprints.

Host Range

Species Affected.—Rice is the major host of this fungus in almost all the rice-growing countries. Wardlaw and McGuire[61] reported its infection on banana in Brazil and Trinidad. According to Anstead[6] this fungus is capable of infecting wheat. McRae[26] reported it in epidemic form sometime on *Eleusine coracana* ; and he found it on *Panicum repens*—wild grass on rice bunds and water channels ; *Setaria italica, Paspalum sanguinale, Triticum vulgare, Panicum ramosum* are also hosts of

this fungus. Strains are distinct in behaviour though morphological and cultural characters are same. Forms on *Oryza, Panicum repens* and *Paspalum* are each restricted to its own host; while those on *Eleusine, Setaria* and *Triticum,* though interchangeable among themselves, will not infect the first three. Its presence has also been noted on *Eleusine indica* in China, and grasses like *Digitaria* in Uganda and United States of America. Nisikado[32] has noted a speices of this fungus on Zingiber in Japan. Tullis[57] stated that blast also attacks crabgrass from which infection may spread to rice. Nisikado and his co-workers[34] have listed the following host plants: Rice (*Oryza sativa* L.), Italian millet (*Setaria italica* Beauv.), *Setaria glauca* (Beauv.), *Zingiber mioga* Rosc., *Zingiber officinale* Rosc., *Costus speciosum* Sm., *Leersia hexadra* Sw., *Panicum paludosum* Roxb., and *Panicum violascens* Kunth., *Setaria viridis* Beauv., *Eriochola villosa* Kunth. and *Panicum miliaceum* L.

Varietal Susceptibility.—Nisikado[32] found as a result of inoculation tests of 430 varieties of cultivated rice that none was entirely immune though over 30 were highly resistant. No constant relation was found between resistance and pH value of the leaf juice of the plants, though in some cases there was an indication that acidity is a determining factor in this connection. He found allied species of *Piricularia* on *Panicum sanguinale, Setaria italica, Setaria viridis, Zingiber officinale* and *Zingiber mioga.* Cross-inoculations showed that each of these species with *Piricularia* spp. from *Panicum miliaceum* and *Eriochola villosa* only infect its own host. Thomas[51] reported that early-maturing varieties showed a relatively lower percentage of infection as they come into flower when the spore bombardment is less intense. Among these are Safeda (immune), Elanikadan, G.E.B. 24, Ps. 67, and Co. 1 (0·5, 0·1, 0·14, 0·5 per cent. of infection respectively). Most resistant varieties are those with relatively narrow and reclining shot blades, a long emergence of the ear and spreading panicles, all of which factors tending to reduce the chances of spore infection. Greater vegetative growth increases susceptibility; so too excessive nitrogen supply in manures.

Sundararaman[45] reported that a number of rice strains tested on their varietal reaction to blast fungus, showed a wide range of variation in their susceptibility. At Coimbatore where the disease was severe and at Aduturai, the G.E.B. 24 variety showed a high degree of resistance while Korangusamba was

very susceptible. Manurial experiments have shown that liberal supply of nitrogen increased susceptibility to *Piricularia oryzæ.*

Thomas[50] found at Coimbatore that Co. 4, 11348, Co. 11, 10998 were resistant. Suzuki[47] found that thickness of outer walls, silicated outermost layer of the epidermal cells, and the number of silicated bulliform cells, silicated long or short cells and silicated stoma are greater in resistant than in susceptible varieties. Number of stomata does not appear to be correlated with the susceptibility of the disease.

Nakatomi[30] has stated that experiments in 1913-14 on comparative susceptibility to rice blast, of a number of native and foreign strains, showed that highest degree of resistance occurred in the varieties from India, Java and Philippines.

Altson[54] has mentioned that Ceylon variety H.J. 16, becomes heavily infected.

Name, History and Range of Disease

Name.—Dodoff and Kovacevski[12] have stated that this disease is known as blast in America ; *imotsi* or *imochibyo* in Japan ; *brusone* in Italy ; Tisdale and Jenkins[55] have called it 'rotten neck', 'leaf-spot', and 'seedling blight' of rice. Chiapelli[9] has termed it 'collar rot' in Italy. Vincens[60] reported that vernacular name for a number of different affections of rice plant which are not distinguished by cultivators is "*tiem*", is believed by pathologists to be caused by the same fungus. In India and Japan it causes serious damage.

In South India it is called "benkiroga" when it affects the seedlings which literally means "fire disease", perhaps due to its spreading like wild fire and also its reddish-brown tinge.

In Japan it has been found associated with *Helminthosporium, Cercospora, Cercosporella, Fusarium, Phoma, Sporotrichum, Septoria, Sphærella,* etc.

Saha[38] has stated that the effect of this disease is variously known in different places—as "falla" in Spain ; "spot-disease" in Bulgaria ; Wardlaw and McGuire[61] have mentioned "spotting or pitting" for the infection of this pathogen on banana in Brazil and Trinidad. Marchionatto[25] has mentioned that the disease is known as "quemado" in Buenos Aires, and was observed for the first time in 1935.

History.—In the posthumous note of Farneti[13] Prof. Montemartini has stated that as early as 1871 Garovaglio attributed

rice blast to an ascomycete *Pleospora oryzæ*. Some years later Cattaneo who originally held this view discovered that a number of other fungi were present on affected plants, none of which could be regarded as primary cause of the disease. Briosi and Cavara found in 1892 that the fungus *Piricularia oryzæ* was the most widely distributed parasite in the affected rice fields, but were unable to trace any direct connection between it and the disease. A special commission nominated by the Ministry of Agriculture to inquire into the matter also failed to secure conclusive proof that *Piricularia oryzæ* was the immediate cause of the blast. Exhaustive researches by this commission into climatic and cultural conditions provided no clue to the origin of the disease. Voglino isolated bacteria from the roots of the diseased plants and maintained in papers published in 1897 and 1903 that 'blast' was due to bacterial rot of the disease. In 1902 Ferraris demonstrated by a series of accurate observations that mycelium of *Piricularia oryzæ* was distinctly parasitic in character attacking the rice plant near the basal node of the ear and producing the typical symptoms of the blast.

The Japanese authorities Miyabe, Hori, Kawakami studying diseases of the same general type as "blast" attributed them in part to *Piricularia oryzæ* and in part to *Helminthosporium oryzæ* of the first two authors. But both they and Ferraris based their views on direct observations only and did not furnish experimental proof of the cause of the disease. Subsequent workers in Japan and America have maintained that blast is caused by *Piricularia* ; and Metcalfe[27] successfully induced the American form of the disease by artificial inoculation with this fungus. On the other hand, Brizi in a series of papers from 1905-08 ascribed the disease to physiological disturbances induced by the effect on the root system, of defective drainage and want of aeration ; and this view was supported by Sorauer and others. Farneti[13] took up the inquiry into the cause of 'brusone' in 1904. After ascertaining that the Japanese and Italian diseases were identical and that the various names of the disease referred merely to different aspects resulting from the more or less advanced stage of the diseased condition, he maintained that the various fungi associated with it were in great part only different forms of the one highly polymorphic species which included *Piricularia oryzæ, Piricularia grisea, Helminthosporium oryzæ, Helminthosporium macrocarpum, Helminthosporium sigmoideum, Cladosporium* sp., *Harmodendron* sp. Farneti affirmed that rice blast is constantly associated with the

fungus in question and succeeded in reproducing all the typical symptoms of the disease by inoculations both from pure cultures and with spores taken directly from the plant. But his studies showed no indications on the resistance of the varieties and the characters of the attack on different parts of the plant and at different stages of its development and the control measures.

Range.—The distribution of this disease encircles the globe, being found practically in all the five continents, as can be seen in the distribution map of plant diseases published by the Imperial Mycological Institute[11] (Fig. 1). It has been found to exist in the following countries.

Africa.—Gold Coast, Kenya (*P. grisea*), Sierra Leone, Tanganyika ; Uganda.

Asia.—Burma, Ceylon, China, French Indo-China, Hawaii (*P. grisea*), India, Japan, Philippines, U.S.S.R. (Central Asia), Malaya, Java.

Australasia : Fiji.

Europe : Bulgaria, Rumania, Italy.

North America : United States of America (Rice-growing States).

West Indies.—Dominican Republic, Puerto Rico.

South America.—Argentina, Brazil, British Guiana, Columbia, Venezuela.

"In Ceylon it has been recorded on *Eleusine coracana*, but *Piricularia oryzæ* does not infect this plant ; while *Piricularia* from *Eleusine coracana* does not infect rice and has been referred to as *Piricularia setariæ* Nisikado."

Piricularia grisea usually regarded as a saprophyte and sometimes confused with *Piricularia oryzæ* but stated by Nisikado to be a parasite restricted to *Digitaria sanguinalis* (Syn. *Panicum sanguinale*) has been recorded in Haiti, Queensland ; and Trinidad, all on banana, besides other countries already listed for *Piricularia oryzæ.*

Tullis[57] has stated that "blast is a serious disease in rice-growing areas except California, most serious in Japan".

Schultz[41] has mentioned that it is a sporadic disease during scanty rainfall periods in Italy.

Saha[38] has stated that this disease has been noted in almost every rice-growing country of the world.

FIG. 1. Distribution Map of Rice Blast.
(From Imperial Mycological Institute Map No. 51, Revised 1-11-1954.)
Pathogen : *Piricularia oryzæ* Cav. Host : Rice.

Africa: Gold Coast
Kenya (*P. grisea*)
Sierra Leone
Tanganyika
Uganda

Asia: Burma
Ceylon
China
French Indo-China
Hawaii (*P. grisea*)
India
Japan
Philippines
U.S.S.R. (Central Asia)

Australasia: Fiji

Europe: Bulgaria
Rumania

North America: U.S.A. (Rice-growing States)

West Indies: Dominion
Republic
Puerto Rico

South America: Argentina
Brazil
British Guiana
Columbia
Venezuela

Importance

Nature of Losses.—Dodoff and Kovacevski[12] have stated that in Bulgaria this disease may practically destroy the whole crop. Tisdale and Jenkins[55] state *Piricularia* (rotten neck) kills the rice heads early preventing them from filling up. Ito[23] has mentioned that the grains became empty and that seedlings died from glume blast. So this disease is known to cause "blast" on young seedlings, appearing in patches and spreading rapidly over whole fields. Once it takes a foothold it spreads like wild fire defying control measures. When it attacks grown-up plants the neck of the earhead becomes affected and the grains empty. Even the leaf-blades get spotted and diseased, becoming unfit for fodder. Tullis[57] has stated that severe infection reduces the yield and lowers the market value.

Amount of Losses.—McRae[26] has noted that this disease has been recorded in different parts of India, but the damage is not considerable. In Madras and Bihar 50 per cent. of the rice seedlings in seed-beds may be infected, but after transplantation may ultimately become almost free from disease. He has found that species of *Piricularia* on *Eleusine coracana* in epidemic form cause 50 per cent. loss. In the Twenty-Third Annual Report of Philippine Islands[35] under plant disease section it is mentioned that this disease causes 30-80 per cent. loss. Tuteffe[58] mentioned that prevalence of spot disease or "brusone" (*P. oryzæ*) causes much concern to rice production in Bulgaria which produces annually 8,508,576 kg., a large portion being exported. Though this disease is very widespread it is not possible to get any exact amount of loss, from literature ; but it is known to cause serious losses in Japan, and occur in varying degrees of seriousness in other countries.

Metcalfe[27] has stated that in South Carolina, U.S.A., it is difficult to estimate the financial loss ; because percentage of loss and percentage of blast are not the same. At a conservative estimate it would be 1¼ millions of dollars, in addition to depreciation in the land value, the other general effects resulting from reduction of crops, abandonment of land and uncertainty of the future of the industry.

Other Aspects.—Vincens[60] has stated that it is a common disease in Indo-China, causing a great deal of damage, disease being commonly known as "tiem". In India and Japan it causes serious damage and is being associated with various other patho-

genic fungi. Hemmi and Endo[18] have found that *Piricularia oryzæ* penetrates the roots of rice seedlings through the soil causing infection and death. This disease is very important in that it overwinters in straw, seeds, and even in stubbles, surviving for long periods, thus being a source of infection and spread in subsequent years. Symptoms of this disease are also confused with those of other fungi, in whose association it occurs, and sometimes it becomes difficult to attribute the disease to the exact pathogen. In Uganda, Small[43] has noted that it consistently reduces the yield, direct remedial measure being impracticable. The disease, according to Thomas, occurs annually on susceptible varieties raised in previously infected fields. Once the disease gains foothold on the crop, it spreads like wild fire, over extensive areas defying all attempts at direct control.

Symptomatology

Morphologic Symptoms.—This is a very destructive disease of rice attacking different parts of the plant. Saha[38] has stated that on one or both the surfaces of the leaves or sheaths reddish or brownish spots are formed. The centre of these spots soon becomes ash-gray, ultimately turning smoky and soiled in colour due to the appearance of spores-sporophores at the region. These minute brownish spots gradually develop into elongated or oval brown areas ½" by ¼". Sometimes the adjacent spots merge together and extend along nearly the whole length on one side of the midrib, or they may extend across it and the leaf gradually withers and dries up. Infection sometimes occurs at the junction of the leaf-blade and sheath. When the flag leaf enclosing the earhead is attacked, the glumes that are in touch with the spots may also be spotted. The ears which appear normal have in most cases the grains improperly filled or almost sterile ; the sterile heads remain standing erect. The greatest damage is caused when the nodes and the necks of the panicles are attacked. Sueda[44] has reported that while symptoms are most conspicuous in leaf-blades, panicles, they are also observable on caryopses, young roots, buds, leaf-sheaths, culm-nodes and flower stalks. According to Ito[23] grains become empty with dark grayish spots on the surface of the hull. Some apparently sound grains show discolouration of scale-like glumes and rachids adhering to them after threshing ; and for this phase of the disease the term "glume-blast" is applied. In the case of *Piricularia cannæ* n. sp., Roldan[37] has stated that in *Canna indica*, leaves affected by foliar blight are characterised by

irregular confluent dark-brown patches, differing from *Piricularia grisea,* in its larger conidia. According to Schultz[41] discolouration of upper parts of shoots, drooping of tips of ears, yellow or chestnut lesions are important symptoms. Yoshii[63] has mentioned that lesions are more numerous on the inner half than on the outer half of leaf-blades.

Rhind[36] has stated that the disease occurs on aerial parts, especially glumes causing absorption of a large number of grains. Tisdale and Jenkins[55] have said that 'blast' is sometimes mistaken to "straighthead" disease which also causes sterile heads ; but the frequent breaking of the heads and the brown discolouration caused by the fungus prevent their being mistaken for "straighthead".

Tullis[57] has recorded that blast is characterised by breaking of entire heads, and by spots on leaves and hulls, leaf-spots long narrow on young leaves, circular in outline on older leaves ; spots found even after they are dead ; the spots brown and similar ; it is difficult to distinguish them except by microscope. Nodes of stem may be attacked. Infected areas on stalk, branches, head or parts of head may break ; it differs with varieties. Seedlings are attacked prior to irrigation, or during the period after the water has been drained off from the field. Under such conditions leaves wither and dry ; sheaths turn brown ; and can be distinguished from "brown spot" disease.

In re-investigating the transit wastage in banana cargoes from Brazil to England, Wardlaw and McGuire[61] found that it was due to infection (invisible when put into cold storage before transit) of bunches in the plantations with *Piricularia grisea* which is a pathogen to rice and other graminæ. Spotting or pitting is typical on cushions, finger-stalks of the two top hands and occasionally on the finger stalks of third and fourth hands ; also on mainstalk and tips of fingers (fruits).

Histologic Symptoms.—The infected tissues lose their turgor and the leaf-blade falls over and such infected regions appear very dark-brown. If the infected region of the leaf-sheath touches the stem inside, the stem may get diseased at that region from where it spreads upward or downward turning the infected tissues almost black. In several cases the stem collapses and bends over at this place. Nagai and Imamura[29] have examined 76 varieties of rice and found that 'neck' anatomy showed more number of stomata with lesser resistance to blast. Suzuki[47]

reported that rice grains or kernels internally infected by *Piricularia oryzæ* or *Ophiobolus miyabeanus* generally show visible discolouration ranging from a small spot or streak to a large area covering the whole surface, sometimes accompanied by shrivelling.

Sawada[40] reported that abnormalities in histological structure of culm nodes, diminution of sclerenchymatous tissue, extension of soft parenchyma impair the resistance of plants to infection by *Piricularia oryzæ*. Before earing leaves are damaged and panicles sustain injuries involving a reduction of grain size and extensive sterility.

In the case of infection on banana, Wardlaw and McGuire[61] have obtained isolations from lesions which gave pure cultures of *Piricularis grisea*. Radial spread of organism and penetration of underlying tissues prepare the way for invasion of secondary fungi, *e.g., Gleosporium musarum, Fusarium* sp., which cause rapid decay and drop of fingers and wastage in transit.

Morphologic Signs.—According to Altson[5] infection commonly takes place on the leaf or at the junction of the leaf-blade and sheath. In the former case minute brown spots gradually developing into elongated oval brown areas with grayish centres, from which conidiophores are extruded, appear on the leaf surface and eventually destroy the whole blade. When infection occurs at the junction of the lamina and the sheath the affected tissues lose their turgor and the leaf falls over. Infection from this point may spread down the sheath and involve the stem. According to Tullis[57] fungus lives on grass or rice straw and infections may spread due to infection sources of crabgrass.

In infection on banana in Brazil plantations the disease has been found to originate in transition or protecting leaves immediately overhanging the bunches and bracts. From these spores are carried to bunches by the downward passage of atmospheric water. The fungus remains dormant until the fruit is reaped and put into cold storage.

Histologic Signs.—Ito[23] has mentioned that hyphæ are readily detected in tissues of straw and seeds. Thomas[52] has mentioned that the straw and the stubble of previously infected crop contain mycelium capable of producing new crops of spores under favourable conditions. Nagai and Imamura[29] have exam-

ined 76 varieties of rice. Neck anatomy showed more number of stomata and lesser resistance to blast. But foreign rice varieties with larger number of stomata were more resistant. So they concluded that there must be some other factor involved in reaction to the disease. Number of stomata is increased by abundant manuring. Suzuki[49] examined seeds inoculated at various times and found hyphæ ramifying to the tissues of embryo, endosperm, branlayers, glumes or between glumes and kernel ; Conidia were also found between glume and kernel.

Etiology

Morphology of Pathogen.—While comparing the Indian "Footrot", "blast" and Japanese "bakane" fungi, Nisikado, Matsumato and Yamauti[34] found that formation of aerial mycelia was poor ; the shape of the colony on agar media being regular and the margins thinner. Microconidia were copious, the surface of the media being covered with white powder. The formation of macroconidia was rich with pionnotes which were flesh-coloured on steamed potato. On steamed wheat agar sporodochial conidium formation was frequently observed. The colour on steamed wheat-agar, steamed potatoes and steamed rind of watermelon, was not produced. On steamed rice, the media and the colonies were a stronger red. Formation of perithecia was rare, while conidial formation was quite common. So their studies on conidia showed that in regard to the mycelium and the conidiophore the Indian fungi showed no difference from that of Japanese fungi.

The hyphæ are colourless, about 2 μ when young and sometimes attain 5". At a distance of 16-60 μ they produce septa where there is little or no constriction. Two types of conidia were produced. Microconidia are produced on tips of aerial mycelium in long chains which may be observed by the naked eye as a white powder over the surface of the medium. The microconidium is colourless, continuous, obovate or longobovate, sometimes elliptical or spherical and contains one or two small light retracting bodies. The size of the microconidia developed on steamed rind of watermelon and on steamed ears of wheat ranged from 6-12 μ and 5-11 μ respectively. Macroconidia are colourless, fusiform or fulcate, more or less curved to one side and narrowing near the apex. They are 0-5 μ septated, but 3-septated conidia are common. Pre-mature conidia have a round apex. At the base it has a papillæ foot. Size varies. In short, it compares very well with Japanese 'bakane' fungi in regard

to shape of conidia and size ; and so morphologically similar to it. Sueda[41] found that conidia vary according to moisture and temperature conditions, being long and narrow in warm, humid surroundings ; small and broad in reverse conditions. In one night more than 10 conidia may develop on a conidiophore. For the formation of each conidium on conidiophore in darkness 5-10 minutes are necessary. Hyphæ and conidia are fairly resistant to dry heat.

Roldan[37] found that in *Piricularia cannæ,* agent of foliar blight of *Canna indica,* the conidia are much larger and are ovate to pyriform, septate, formed terminally in a scorpioid cyme and measures 35-49 by 14-21 μ.

Venkatrayan[59] found that a strain of *Piricularia oryzæ* produced grey-coloured mycelia and spores, and to form dark chalmydospore.

Name, History and Classification.—Farneti[13] has stated that as early as 1871 Garovaglio attributed the rice blast fungus to an ascornycete—*Pleospora oryzæ.* Some years later Cattaneo who originally held this view discovered that a number of fungi were present on the affected plant, but none of which could be held as the primary cause of the disease.

Briosi and Cavara found in 1892 that *Piricularia oryzæ* was most widely distributed in the affected rice fields but were unable to trace any direct relationship of the fungus with the disease. Ferraris demonstrated that mycelium of *Piricularia oryzæ* was distinctly parasitic in character attacking the rice plants. Japanese authorities—Miyabe, Hord and Kawakami—also attributed 'blast' to *Piricularia oryzæ.* Later workers in Japan and America maintained that 'blast' was caused by *Piricularia* and Metcalfe induced the disease by artificial inoculations.

Farneti maintained that the various fungi associated with 'blast' were different forms of one highly polymorphic species which included *Piricularia oryzæ* ; *Piricularia grisea* ; *Helminthosporium oryzæ* ; *H. macrocarpum* ; *H. sigmoideum* ; *Cladosporium* sp. and *Harmodendron* sp.

Nisikado[32] has adopted the name *Piricularia oryzæ* for the rice 'blast'; *Piricularia grisea* ; *Piricularia setariæ* ; *Piricularia zingiberi,* for the allied organisms. He further compared the Indian 'blast' fungus and found to be similar to the Japanese 'bakane' disease fungus and has stated that it belongs to Ascomycetes.

Altson[5] and Bunting[8] have termed the fungus attacking rice in British Guiana and Gold Coast respectively as *Piricularia grisea*. Wardlaw and McGuire[61] have said that the causal organism of banana spotting in Brazil is *Piricularia grisea* which is a pathogen to rice and other graminæ. McRay[26] has stated that the cause of rice 'blast' is *Piricularia oryzæ* and its strains on other hosts are distinct in behaviour, though morphological and cultural characters are same, each being restricted to its own host. All the other workers in Japan, India, Europe and America have termed the 'blast' fungus as *Piricularia oryzæ*.

The name *Piricularia* is preferred by some ; and *Dactylaria* by other workers ; Nisikado[32] has preferred *Piricularia*. Since the species show morphological and physiological differences, he has adopted the names : *Piricularia oryzæ* Briosi et Cavara for the rice 'blast' fungus ; and *Piricularia grisea* (Cooke) Sacc. for the fungus on crabgrass—*Panicum sanguinale* L. A new name *Piricularia setaria* Nisikado was proposed for the fungus found on Italian millet (*Setaria italica* Beauv.) and green fox tail (*Setaria viridis* Beauv.) ; and *Piricularia zingiberi* Nisikado, for that on ginger (*Zingiber officinale* Rosc.) as well as that on *Zingiber mioga* Rosc.

On the basis of Farneti's statement that Garovaglio attributed the rice 'blast' fungus to an ascomycete and that according to Nisikado and his co-workers, perithecia are found but rare, the fungus will have to be placed under Ascomycetes; but since perithecia are not common, and formation of conidia is copious, it will have to be classed under *Fungi Imperfecti*. Heald[15] in his *Manual of Plant Diseases* has classified *Piricularia* under Monilaceæ of *Fungi Imperfecti*.

Pathogenicity.—Hemmi and Yokogi[20] conducted a number of inoculation experiments with the disease-free seedlings on nutrient agar in flasks and tubes which confirmed the existence of group of fungi causing foot and root-rot of rice plants. The organisms used were from common rice pathogens isolated from aerial parts of plants, *e.g., Piricularia oryzæ, Helminthosporium oryzæ, Hypochnus sasakii*, etc.; of these *Helminthosporium oryzæ* penetrated the roots easily and caused blast of basal portion of seedlings. Next in virulence came *Piricularia oryzæ*. They concluded that the plants are liable to infection by a number of fungi when grown under conditions favouring the development of the latter. Hemmi and Abe[17] found that experiments in which rice seedlings sprayed with spore suspension of *Piri-*

cularia oryzæ held in moist chambers at various constant temperatures indicated the minimal period of continuous wetting to produce leaf infection to be 10 hours at 32°, 8 at 28°, 6 at 24° and 6-8 at 20°. At 34° infection was scarcely possible. Optimum temperature for rapid development of initial stages of leaf infection was found to range from 24° to 28° agreeing closely with that for the best growth of the fungus. Hemmi has further stated that results of inoculation experiments with the causal organism of rice blast (*Piricularia oryzæ*) on plants grown in soil of varying moisture contents indicated that the more humid the soil, the lower the rate of infection, and conversely the longer the duration of dry period, the higher the incidence of blalst. He and his co-worker Endo[18] found *Piricularia oryzæ* penetrating the roots of rice seedlings through the soil causing infection and death. Possibility of infection depends greatly on the moisture contents of the soil. If there is a layer of water on the surface of soil infective capacity of the fungus is very slight partly on account of its development being suppressed by lack of O_2.

Suzuki[48] found that both *Piricularia oryzæ* and *Ophiobolus miyabeanus* were capable of infecting the seeds from their origin to after maturity and also young seedlings shortly after germination in the spring, producing visible discolouration ranging from a small spot or streak to a large area covering the whole surface, sometimes accompanied by shrivelling.

Thomas[50] reported that cross-inoculations with strains of *Piricularia* from *Eleusine coracana, Setaria italica* and rice showed that those from *Eleusine coracana* and *Setaria italica* infected their own host, two lines of wheat, oats, barley, maize and *Dactylotenium ægyptiacum* (*Eleusine ægyptiacum*), but not rice ; whereas *Piriculăria oryzæ* from rice attacked all plants except *Eleusine coracana.*

Nisikado[32] reported that cross-inoculations with species of *Piricularia* from *Panicum miliaceum* and *Eriochola villosa* showed that each species only infected its own host. Optimum temperature for mycelial growth of *P. oryzæ, P. setaria* and and *P. grisea* was found to be 26-28° C., while *P. zingiberi* developed best at 23-24° C. Maximum for the three of the first-named species was 36-37° C., and that for the last 34-35° C. The minimum for the growth of all species was 8-9° C., the thermal death-point, 51-52° C. He has also reported that results of inoculations of 430 varieties of cultivated rice showed that none

was entirely immune though over 30 were highly resistant. No constant correlation was found between resistance and pH value of the leaf juice of the plants though in some cases there was an indication that acidity is a determining factor in this connection.

Anstead has mentioned that *P. oryzæ* is capable of infecting wheat.

Variability.—Nisikado[34] and his collaborators while comparing Indian 'foot rot' fungus with Japanese 'bakane' fungus found in culture it produced micro- and macro-conidia richly. Formation of aerial mycelia was poor ; shape of the colony on agar media was regular and margins thinner. Sporodochia formed frequently on steamed wheat agar. On steamed rice the colour of the fungus was red. So in cultural characters it differed from 'bakane' fungus and they might be different physiologically but the divergences were not great.

Sundararaman[46] found that fragments of rice leaves showing *P. oryzæ* spots collected in December and kept in dry petri dishes and germination tested for 9 months by placing spores from these specimens on slides in moist chambers at monthly intervals, still germinated after 5 months freely ; and by the end of 6 months the germination had fallen down to 2 per cent. while after 7 months only occasional germination was observed. So the period of viability of the spores covers the interval between one rice crop to another, *viz.*, January to February till July to August.

Hemmi and Imura[19] sprayed conidial suspension of *P. oryzæ* on rice leaves and placed them in desiccators after appearance of spotting, air kept at constant humidity and found that fungus produced conidia in spots in air of 93 per cent. or more relative humidity. There was a higher tendency to produce 2 germ tubes from 1 conidium in a strain of high than one of low pathogenicity.

Abe[2] reported that optimum temperature for mycelial growth in the strain of *P. oryzæ* was found to be about 28° C., at which point the development of the fungus was stimulated by addition of $CuSO_4$ to the agar medium at concentrations between 1/400 and 1/6,000 mol. This stimulatory action was not apparent at 20, 24, 32 and 36°. Conidial formation was retarded at all temperatures, in the inverse ratio to the amount of $CuSO_4$ at concentrations above 1/6,000 mol.; under which

conditions chlamydospores were formed at all temperatures tested, while the colour of the colonies underwent striking changes.

Hiriyama[21] added glucose or glycerine to potato decoction agar cultures of *P. oryzæ* to make solutions of different osmotic pressure. Mycelial growth was vigorous in the media of higher osmotic pressure.

Abe[1] found that infection was intense on seedlings kept in darkness, and that light inhibits development of fungus to some extent.

Tochinai and Shimamura[56] found divergent cultural characters on various nutrient media. They differentiated 6 growths on apricot juice agar ; 4 on onion decoction agar ; 3 on rice plant decoction agar ; and 3 on peptone-sucrose synthetic agar ; 9 physiologic forms were distinguished on the basis of cultural difference on the abovementioned media.

Venkatrayan[59] found a strain of *P. oryzæ* from ragi, *Eleusine coracana,* earheads showing in cultures prominent gray colour in the mycelium and spores ; and to form dark chalmydospores.

Wardlaw and McGuire[61] have reported that isolations from lessions on infected banana gave pure cultures of *P. grisea.*

Life-History

Primary Cycles : *Pathogenesis* (Fig. 2)

Inoculation.—Suzuki[41] has stated that spores are conveyed by wind 40 m. away ; free at a distance of 80 m. from focus.

Incubation.—Conidia may germinate according to Sueda[44] in 12-16 hours after they begin to be produced. Their germination can take place between 15-20° C., optimum being 25-28° C. Conidia produced under dry conditions germinate better than those formed under moist conditions. When very moist conidia are unable to germinate but do so when dry conditions are restored. They germinate in an acid than an alkaline reaction while they as well as hyphæ grow better under the latter than under the former. Sunlight exercises great influence in every stage of development ; especially direct sunlight greatly delays germination as well as growth. But conidia and hyphæ are resistant to temperatures under dry conditions. When conidia are

subjected to 60° C. for 30 hours about half of them survive ; when placed in water at 50° C. for 13-15 minutes all die.

When conidia germinate appressoria are formed at the apex of germ tubes. The appressoria which have been mistaken for chlamydospores are thick-walled cells secreting a mucilaginous substance by which they adhere to the host's surface. The germ tubes and appressoria enter the host through stomata and epidermal cells themselves. Conidia were observed to survive for one year on the host out of doors, or even for two years in nutrient media. They may live long floating on water surface of a rice field but will die within two weeks when they sink.

Shimada[42] has stated that *Piricularia oryzæ* penetrates rice leaves through the cuticle especially that of the guard and accessory cells. Conidia germinating on the leaf surface from appressoria which send out slender infection hyphæ into cell tissues. These appressoria may be produced not only on rice leaves but also on those of other plants not susceptible to *Piricularia oryzæ*, without necessarily causing infection ; and even on glass discs. Foliar injury was found to cause an appreciable increase of infection by the blast organism.

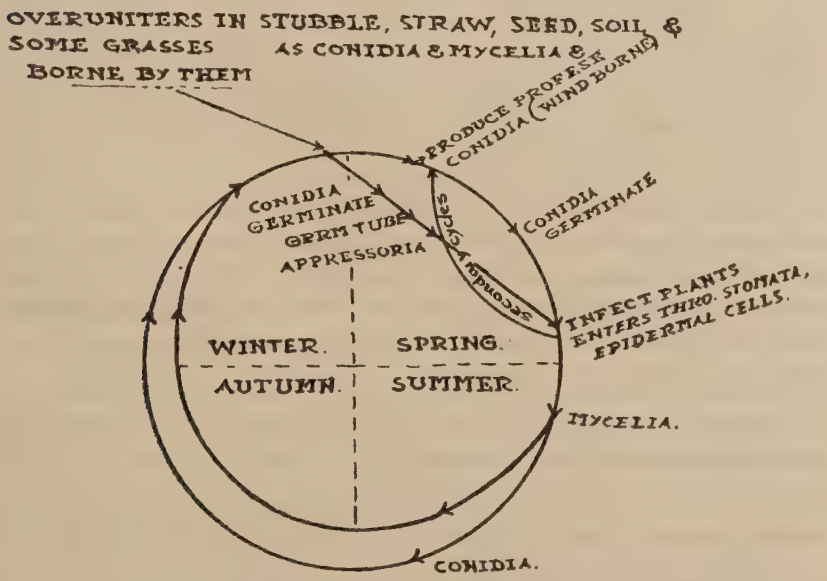

FIG. 2. Life-cycle of *Piricularia oryzæ* Br. et Cav.

The organism survives winter as conidia and mycelia in stubble, straw, Seed, soil and some grasses.

Infection.—Profuse conidial formation occurs from the overwintered mycelium in damp conditions at 18-36° C. Healthy rice plants are liable to infection by overwintering conidia as well as by those formed on the mycelium in diseased plant debris under moist conditions. Conidia from surface of apparently healthy seeds of diseased plants are capable of infecting the tissues of partly blasted seeds which later give rise to wilted seedlings.

Saprogenesis

The pathogen overwinters on straw, stubble and also in soil as conidia and mycelia. In the distribution map[11] of this disease from Imperial Mycological Institute it is mentioned that *Piricularia grisea* usually regarded as a saprophyte and sometimes confused with *Piricularia oryzæ* but stated by Nisikado to be a parasite restricted to *Digitaria sanguinalis* (syn. *Panicum sanguinale*).

Ingold[22] obtained a new species of *Piricularia* commonly occurring on submerged decaying leaves in well aerated water with abundant development in fall and winter. Kuribayashi[24] has stated that overwintering conidia retain their viability for over a year at room temperature under dry conditions; while they overwintered in soil or in farmyard manure only remained alive until spring. Mycelium in diseased nodes retained its viability for nearly three years under dry conditions whereas in damp atmosphere it ceased to grow in the spring of the next year.

Dodoff and Kovacevski[12] found *Piricularia oryzæ* overwintering as conidia on rice seeds, straw and infected stubble; and as mycelium on straw and stubble. Conidia retain viability for over 17 months at room temperature and dry conditions and mycelium survived for over 28 months under the same conditions in diseased rice nodes.

Suzuki[48] found *Piricularia oryzæ* hibernating at least two years in grains without losing its viability.

Schultz[41] reported that the pathogen overwinters in soil and in summer attacks wild grass (*Panicum sanguinale*).

Secondary Cycles.—The conidia are wind-borne. When conidia are produced from infected plants, they are distributed by wind and fresh healthy plants are attacked. The disease is known to appear in patches first and very soon spread over

extensive areas, which can be possible by secondary cycles, the spores being disseminated by wind.

Epiphytology

Nisikado[32] has reported that severe outbreaks occur on foliage on the resumption of fine weather in June or July following a protracted damp cool spell. The ears, particularly necks become affected during cool rainy weather at the flowering season in September. Excessive use of green manures, *e.g.*, *Astragalus sinicus* has been found to favour leaf blast on heavy soils ; and the rotten-neck condition on sandy ground. He has obtained beneficial results from the application of superphosphate and addition of lime gypsum or $CaCO_3$ to the manures. Drainage of sandy soils was found to increase rather than retard the development of the disease.

Tisdale[54] reported that this disease is favoured by humid atmosphere and high temperatures, storage of rice in damp places, transit in warm damp cars for considerable distances. Spores lodge in between glumes at flowering time and infection spreads if rice is stacked under warm moist conditions.

Thomas[51] found that in any one variety the late sown suffered less than the early sown crops, difference being attributed to more frequent rain, cloudy dry and increased relative humidity during early period. He reported that in pot tests application of ammonium sulphate and sodium nitrate at rates equivalent to 40, 80, 160, 240 lb. of nitorgen per acre increased infection by *Piricularia oryzæ* in susceptible varieties. For equal amounts of nitrogen, sodium nitrate induced greater susceptibility than ammonium sulphate. Disease occurs annually on susceptible varieties raised in previously infected fields. Once the disease gains foothold on the crop it spreads like wild fire over extensive areas defying all attempts at direct control.

Schultz[41] has mentioned that an epidemic occurred in 1943 in Tucuman. McRay[26] has mentioned that infection experiments revealed that high moisture contents of air and a definite temperature are important in influencing spread and severity of the disease.

Bunting[8] has recorded that in Adebrem—gold coast in the early part of wet season in 1924, rice crop was threatened with damage from *Piricularia grisea* which causes epidemics of blast. It was arrested by a drought in July. Considerable differences

in varietal susceptibilities have been reported. Recovery of affected plants was retarded wherever an accumulation of wood ash was found in the soil.

According to Farneti[13] it is characteristic of 'brusone' that alternating periods of virulence and mildness occur—the disease temporarily disappearing as a result of new cultural methods or the introduction of improved strains, only to return with renewed severity. He found in 1909 that the disease stopped due to introduction of resistant foreign varieties.

Tullis[57] has stated that blast attacks crabgrass from which infection may spread to rice. Fungus lives on grass or rice straw ; severe infections in new fields are due to infection source of grass.

Control

Exclusion.—In Brazil there is a law to prohibit transit of diseased rice from places of infection. California is also protected by quarantines in this respect.

Eradication.—Fawcett[14] has advised exclusion of fodder grasses susceptible to blast ; and to grow maize, lucerne, etc., in infected fields for 1 or 2 years before again growing rice. Tullis[57] has mentioned that blast is reduced in early stages by submerging the seedlings when leaf-spots appear. Nakatomi[39] has stated that dry spell immediately after infection reduces the disease. This fact was confirmed by an experiment in which more lesions occurred on plants kept at a humidity of 94 than on those kept at 78·4.

Protection.—There is a general quarantine embargo against bringing viable rice seed into California to prevent the introduction of any rice diseases and pests. Tisdale[54] has advised seed treatment—immersion in hot water at 54° C. for 15 minutes preceded by pre-soaking in tepid water for 16 hours. This method was found to be laborious and expensive. Small[43] has stated that direct remedial measures are impracticable. He has advised sanitary measures like burning of refuse, good cultivation and the like. Sawada[40] found that of the three essential fertilisers, nitrogen, phosphate and potash, the first-named in the course of seven years observation in Formosa affected marked development of rice blast ; incidence rose parallel with additional amount of N_2, which induced a decline in the thickness of leaves and of their epidermal cell-walls coupled with an increase in

the number and size of stomata. So excessive use of nitrogen must be avoided. Wardlaw and McGuire[61] have advised against banana pitting by *Piricularia grisea* weekly or fortnightly inspections and cutting the transition leaves by a sharp knife and detaching the bracts carefully. This treatment is simple and inexpensive. Sunscorch of bunches may be avoided by bending down an overhanging leaf.

Metcalfe[27] has advised use of lime and marl which produce a good growth of rice and do not predispose the rice to blast, but exert a retarding effect on the disease. There is a good possibility in the use of lime and marl in combination with phosphoric acid and potash.

Kuribayashi[24] recommended that heavily infected straw should be burnt or mixed with farmyard manure and fodder. He too recommended hot water treatment for the control of the fungus in the seed.

Dodoff and Kovacevski[12] have stated that fields must be well aerated ; and advised burning of stubble ; crop rotation ; isolation of infected parts of rice fields.

Tuteffe[58] conducted some experiments for seed treatment at Sadovo Experiment Station, Bulgaria, to determine the value of seed disinfection with Kalimat B in the control of the disease. Seeds of indigenous pembe variety (76·6 per cent. of total crop) were treated. One lot was steeped in 0·5 per cent. solution of Kalimat B for 1 hour after 23 hours of pre-soaking ; another lot was immersed in the same preparation at 0·2 per cent. for 24 hours. The latter treatment gave better results reducing the incidence of infection to a minimum and effecting a considerable increase in the yield. A marked stimulatory action also resulted from the process.

Chiapelli[9] has stated that the "brusone"—collar-rot fungus is associated with excessive soil fertility, in particular, superabundance of N_2. In new plantations where disorder is prevalent, he recommended use of superphosphates and potassium chloride at 8-10 to 3-4 quint per hectare respectively. In old fields, continuous use of calcium cyanamide at 3-4 quints per hectare markedly improved the chemical condition of the soil ; while a further amelioration may be effected by winter application after ploughing, of quicklime at 3-4 quints ; or 8-10 quints of ground calcium carbonate per hectare.

The other factors contributing to occurrence of brusone are stagnant water in fields and sudden fall of temperature. Stagnant waters may be drained off. Mention has been made in the Mycology Report[28] of the Department of Agriculture, Burma, for 1941-42 and 1942-43 that immersion of seedlings in a 2 per cent. $CuSO_4$ solution before transplanting gave encouraging results.

Saha[38] has mentioned that in Italy and United States of America this serious damage caused by the disease has been prevented by spraying the plants with Bordeaux mixture while it is in the seed-bed ; beneficial results have been obtained elsewhere by application of lime, calcium carbonate or gypsum to manures. Application of heavy doses (60 lb. per acre) of nitrogen in the form of ammonium phosphate makes the plant susceptible to blast while smaller doses are said to be beneficial. The effect of nitrogen can be counteracted to a good extent by the application of potash but not by phosphoric acid. Soaking of seeds in 2 per cent. solution of Kalimat B for 24 hours not only reduces greatly the incidence of the disease but is said to have a beneficial effect towards increasing the yield.

Immunisation.—Nakatomi[30] conducted a number of experiments in 1913-14 on comparative susceptibility to rice blast, of a number of native and foreign strains which showed that the highest degree of resistance occurred in the varieties from India, Java and Philippines.

Sundararaman[45] carried a large number of experiments in India and found several highly resistant varieties. E.B. 24 was highly resistant while Korangusamba was very susceptible.

Thomas[52] stated that early-maturing varieties showed a relatively lower percentage of infection as they come into flower when the spore bombardment is less intense. Among these are Safeda (immune), Elanikadan, EB. 24, Ps. 67 and Co. 1 (0·5, 0·1, 0·14, 0·5 per cent. of infection) respectively. Most resistant varieties were those with relatively narrow and reclining shot blades, a long emergence of the ear [length of the flower stalk between the base of the shot blade and the neck], and spreading panicles, all of which factors tending to reduce the chances of spore infection. Greater vegetative growth increased susceptibility ; so too ; excessive N_2 supply in manures ; while potash and phosphoric acid exerted a slight inhibitary action on infection.

In manurial pot tests, application of ammonium sulphate and sodium nitrate at rates equivalent to 40, 80, 160, 240 lb. of N_2 per acre increased infection by *Piricularia oryzæ* in susceptible varieties. For equal amounts of N_2 sodium nitrate induced greater susceptibility than ammonium sulphate. Most resistant variety Co. 4 remained unaffected by heavy doses of N_2. In monthly planted varieties highest infection occurred in August sowings, but even in these varieties 10998; Co. 11; ADT. 6; and Co. 4, remained fully resistant. Thomas[53] has also reported that three strains of G.E.B. 24 × Korangusamba crosses developed at Coimbatore were highly resistant and the yield 10-18 per cent. more than the original Korangusamba stock.

Cralley and Adair[10] have mentioned the hybrids—Arkrose and Prelude to be resistant in Arkansas. Savulesco[39] has mentioned the hybrid Biaz × Moratelli to be resistant in Roumania.

Suzuki[47] from his experiments concluded that thickness of outer walls, silicated outermost layer of the epidermal cells and the number of silicated bulliform cells, silicated long or short cells and silicated stomata are greater in resistant than in susceptible varieties ; and on flooded than on dry soil, while the number of stomata does not appear to be correlated with the susceptibility of the disease.

Nagai and Imamura[29] found that neck anatomy with more number of stomata showed less resistance to blast ; but foreign varieties with larger number of stomata are more resistant ; so there must be some other factor involved in reaction to the resistance.

Number of stomata are increased by abundant manuring. Yoshii[62] showed in experimental tests that application of silicic acid to soil enhances the resistance of rice to blast, with foliar toughness measured by needle puncture or tearing method.

Akai[4] found that plants coming from moist soil were more resistant than those from dry soil ; the number of silicated epidermal cells per unit area of leaf which are penetrated by the fungus is larger in plants transplanted from dry beds.

Many of the workers have stated that resistant varieties are the best means of preventing the disease.

Therapy.—Ito[23] found that conidia were killed when frozen in water but they withstood 45 days at 4° C.; some intracellular hyphæ remained viable for the same period in a frozer condi-

tion. Conidial death point of *Piricularia oryzæ* subjected to disinfectants ; $CuSO_4 = 2$ per cent., $HgCl_2 = 0{\cdot}05$ per cent., Formaldehyde $= 0{\cdot}175$ per cent., hot water $= 5$ minutes at 52° C. Formaldehyde was found to be most efficacious.

Suzuki[41] found that the pathogen from the interior of the grains is killed in minutes by immersing in hot water at − 50° C.

Nisikado[32] found that spores when attached to glumes on rice were easily killed by dilute fungicides ; but the destruction of mycelium within the tissue of the culm nodes or grains presents greater difficulty.

Fawcett[14] recommended dusting of flowers of sulphur against the disease in Tucuman. Narasimhan[31] in India found flowers of sulphur dusted on a small plot of rice showing infection of *Piricularia oryzæ,* controlled largely the fungus. This is now being generally advised to the rice cultivators in the control of this disease.

Abe and Okamura[3] found that susceptibility was inversely proportional to the quantity of $CuSO_4$ given, through the roots of seedlings and adult plants in soil and water cultures.

Metcalfe[27] has stated that spraying of Bordeaux 5 : 5 : 50 perfectly controls the disease, but there is difficulty in spraying the fields.

Summary

In addition to rice, 'blast' is found to occur on banana, Canna, *Eleusine* sp., *Panicum* sp., *Setaria* sp., *Triticum vulgare, Paspalum* sp., *Digitaria* sp., ginger, *Costrus speciosum, Leersia hexandra* and *Eriochola villosa.*

Rice blast is known since 1871 and is called by various common names in different countries. It occurs practically in all the rice-growing countries of the world.

The loss occasioned by this disease is total, particularly in Japan ; and not quite serious in other countries.

The familiar symptoms of the disease are reddish brown spots on the leaves, sheaths, stems and seeds ; rotten neck or brown shady affected area at the neck ; and empty grains in the earhead.

The taxonomy of this fungus is disputed because number of closely allied species occur on rice affected by blast. *Piricu-*

laria oryzæ Bri. et Cav. is taken to be the pathogen of rice blast; and *Piricularia grisea* (Cooke) Sacc., occurs on crab-grass—*Panicum sanguinale* and banana and is a very closely allied species, sometimes confused with *Piricularia oryzæ*, but morphological and physiological differences have been found. The other species of *Piricularia* occur on graminæ, Canna and other plants.

The pathogen overwinters as mycelia and conidia in stubble, straw, seeds, soil and some grasses, which are the sources of infection in the next spring.

A number of epiphytotics have occurred. The disease is favoured by humid atmosphere, high temperature and excessive green manure. Once the disease takes a foothold, it spreads quickly like wild fire over extensive areas, defying all attempts at direct control.

Direct control measures are difficult. Resistant varieties are helpful. A number of rice varieties have been found to be highly resistant to 'blast' in different countries. Excessive use of N_2 in the manures must be avoided. Use of lime and marl has given encouraging results. Affected straw, stubble, crab-grass should be burnt.

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References

1. Abe, T. (1932), "On the Effect of Sunlight in the Infection of Rice Plant by *Piricularia oryzæ*", *Forsch.. Aus. Dem. Geb. der. Pflanzenkrankh. (Kyoto)*, 1, 46-53, (1931), Japanese [German Abs. in *Jap. Jour. of Bot.*, 6 (2), 27, (1932).]
2. ——— (1930), "On the Influence of $CuSO_4$ to the Growth of *Piricularia oryzæ* with Special Reference to Temperature as an Environmental Factor", *Ann. Phytopath. Soc. Japan*, 11 (3), 171-96, 11 graphs. (Japanese with English summary.)
3. ——— & Okamura, E. (1932), "On the Influence of $CuSO_4$ upon the Susceptibility of Rice Plant to the 'Blast' Disease", *Forsch. Aus. dem. Geb. der. Pflan. (Kyoto)*, 1, 54-70, (1931), Japanese [Abs. in *Jap. Jour. of Bot.*, 6 (2), 27, (1932)].

4. Akai, S. (1939), "On the Ash Figures of Leaves of Rice Plants Transplanted from Different Kinds of Nursery Beds and Their Susceptibility to the Blast Disease", *Ann. Phytopath. Soc. Jap.*, 9 (4), 223-35.
5. Altson, R. A. (1926), "Report of the Assistant Botanist and Mycologist", *Report of Dept. of Sci. and Agri. Brit. Guinea for the Year* 1924, *Appendix III*, 45-54.
6. Anstead, R. D. (1924), *Report on the Operations of the Dept. of Agri., Madras Presidency, for the Official Year* 1922-23, 30, Map 1.
7. Bryce, G. (1921), "Report on the Work of the Botanical and Mycological Division", *Report Dept. of Agri. Ceylon*, 13-15, (1920).
8. Bunting, R. H. (1924), "Report of the Research Branch (January 1, 1922 to March 31, 1923)", *Rept. Dept. Agri. Govt. Gold Coast, Appendix A*, 19-23.
9. Chiapelli, R. (1938), "Mezzi di difesa contro il brusone del Riso (Methods of Combating Brusone of Rice)", *G. Risiclt.*, 28 (4), 63-66.
10. Cralley, E. M. and Adair, C. R. (1942), "Rice Blast in Arkansas", *U.S.D.A. Plant dise Reporter*, 26 (6), 149-50.
11. ——— (1944), "Distribution Map of Plant Disease", *Imperial Mycological Institute*, 51.
12. Dodoff, D. N. and Kovacevski, I. C. (1930), "Preliminary Study of the Blast Disease of Rice in Bulgaria", *Sci. Trans. Bulgarian Agri. Soc. Sofia*, 25-61, pl. 5, graphs 2. (English summary.)
13. Farneti, R. (1921), "Sopra il 'brusone' del Riso (On the 'Blast' of Rice)", *Att. l Botan. del. uni. dipavia. ser.*, 2 (18), 109-15. pl. 10.
14. Fawcett, G. L. (1935), "A New Rice Disease in Tucuman Blast—*Piricularia oryzæ*", *Cir. Estat. Expt. Agri. Tucuman*, 42 (6), Fig. 1.
15. Heald, F. D. (1933), *Manual of Plant Disease*. (McGraw-Hill Book Company, Inc., New York and London), 669.
16. Hemmi, T. (1930), "On the Relation of Soil Moisture to Development of Rice Blast Disease", *Agri. and Horti.*, 4, 1143-154, pl. 1 (1929). Japanese. [Abs. in *Jap. Jour. of Bot.*, 5 (1), 4, (1930)].
17. ——— and Abe, T. (1931), "On the Relation of Temperature and Period of Continuous Wetting to the Infection of Rice Plant by *Piricularia oryzæ*", *Forsch. aus. dem. Geb. der. pflanzenkrankh (Kyoto)*, 1, 35-45.
18. ——— and Endo, S. (1930), "On the Possibility of Soil Infection of *Piricularia oryzæ* and Its Relation to Soil Moisture", *Agri. and Horti.*, 4, 773-84, pl. 1, (1929). Japanese [Abs. in *Jap. Jour. Bot.*, 5 (1), 4 (1930)].
19. ——— and Imura, J. (1939), "On the Relation of Air Humidity to Conidial Formation in the Rice Blast Fungus, *Piricularia oryzæ*, and the Characteristics in the Germination of Conidia Produced by the Strains Showing Different Pathogenicity", *Ann. Phytopath. Soc. Jap.*, 9 (3), 147-56. (Japanese with English summary.)

20. Hemmi, T. and Yokogi, K. (1928), "Experimental Study on the Pathogenicity of Certain Fungi on Rice Seedling", *Mem. Coll. Agri. (Kyoto) IMP. v. Univ.*, 7, 1-22, pl. 2, graph 1.

21. Hiriyama, S. (1932), "On the Influence of Osmotic Pressure of Culture Media on the Mycelial Growth of *Piricularia oryzæ*", *Bri. et. cav. Forsch. aus. dem. Geb. der. Pflankenkrankh (Kyoto)*, 1, 27-32, Figs. 2, (1931). Japanese with English summary [Abs. in *Jap. Jour. of Bot.*, 6 (2), 33, (1932)].

22. Ingold, C. T. (1944), "Some New Aquatic Hypomycetes", *Trans. Brit. Mycol. Soc.* 27 (½), 35-47, pl. 2, Figs. 8.

23. Ito, S. (1932), "Primary Outbreak of the Important Diseases of the Rice Plant and Common Treatment for Their Control", *Hokkadio Agri. Expt. Sta. Report*, 28, 211, pl. 7, col. 1, graphs 7, Received May 1933. (Japanese with English summary.)

24. Kuribayashi, K. (1928), "Studies on Overwintering, Primary Infection and Control of Rice Blast Fungus—*Piricularia oryzæ*", *Ann. Phytopath. Soc. Jap.*, 11 (2), 99-117. (Japanese with English summary.)

25. Marchionatto, J. B. (1942), "Nota experimental sobre el. 'quemado' del arroz. *Piricularia oryzæ*", *Br. et. Cav. Agronomia* (Buenos Aires), 30 (4), 351-54.

26. McRae, W. (1922), "Report of the Imperial Mycologist", *Agri. Res. Inst. Pusa Sci. Reports*, 1921-22, 44-50.

27. Metcalfe, H. (1906), "A Preliminary Report on the Blast of Rice", *S. C. Agri. Expt. St. Bull.*, 121.

28. Mycology (1943), *Report of Dept. Agri. Burma*, 1941-42 *and* 1943, 4-9.

29. Nagai, I. and Imamura (1931), "Morphology of the 'neck' of the Panicle as Related to the Resistance against Disease in Rice Varieties", *Ann. Agri. Expt. St.*, (Gov.-Gen. chosen), 5, 289-304, pl. 3, (1931). Japanese (Abs. in *Jap. Jour. of Bot.*, 5 (4), 101-02.

30. Nakatomi, S. (1927), "On the Variability and Inheritance of the Resistance of the Rice Plants against the Rice Blast Disease", *Jap. Jour. of Genetics*, 4, 31-38. Japanese [Abs. in *Jap. Jour. of Bot.*, 111 (4), 101-02.]

31. Narasimhan, M. J. (1936), "Report of Work Done in the Mycological Section for the Year 1934-35", *Adm. Rept. Agri. Dept., Mysore*, 1934-35, 19-22.

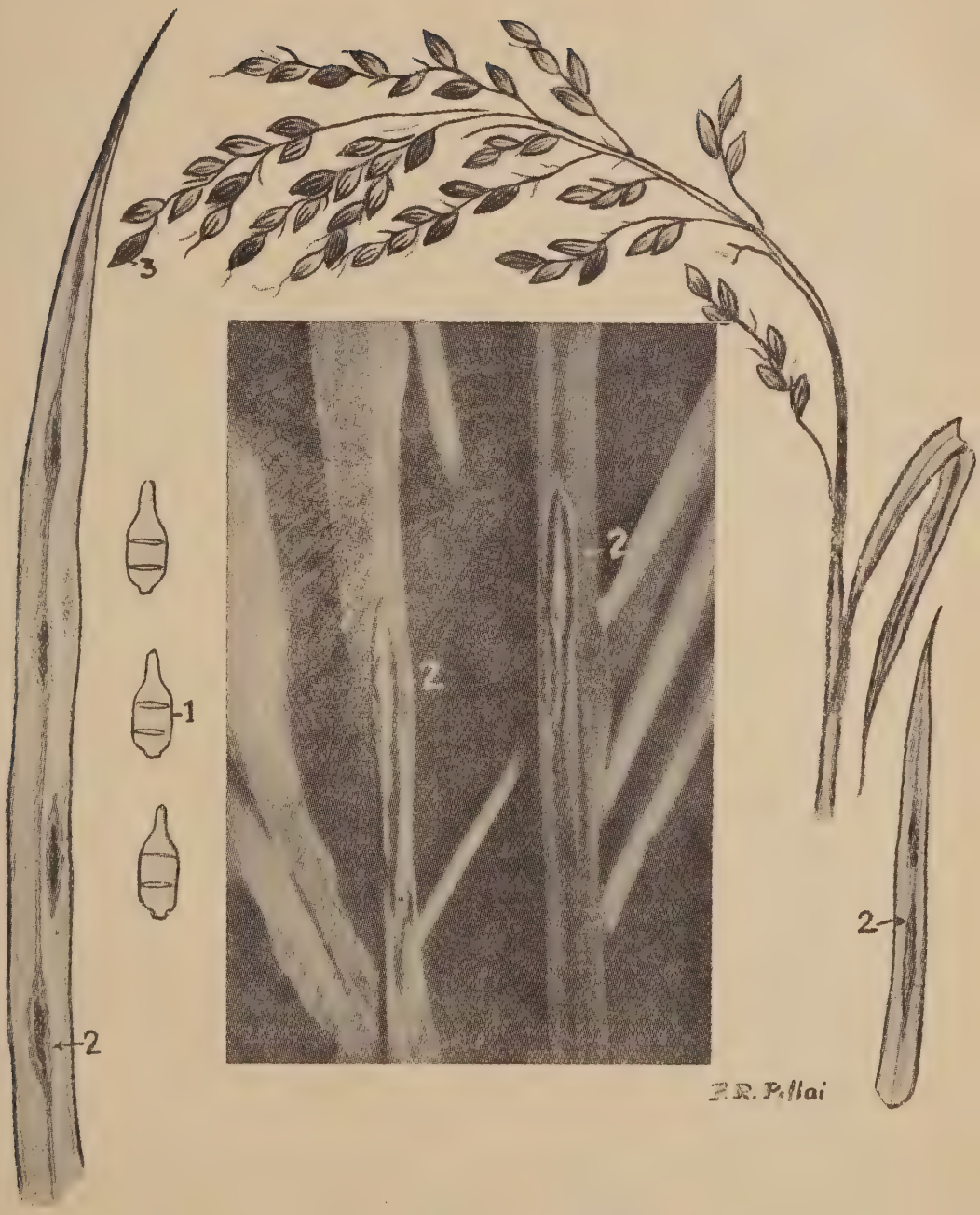
32. Nisikado, Y. (1927), "Studies on the Rice 'Blast' Disease", *Jap. Jour. of Bot.*, 111 (3), 239-44.

33. ——— (1917), "Studies on the Rice 'Blast' Fungus", *Ber. Ohara Inst. Landw. Forsch.*, 1, 171-218.

34. Matsumoto, H. and Yamauti, K. (1934), "Berichte des Ohara Institute fiir Landwirtschaftliche Forschungen in Kurashiki, Provinz Okayama, Japan", "Comparative Studies on Two Rice Fungi", "The Foot-Rot Fungus of India and the 'Bakane' Fungus in Japan", *Band* 6, *Heft* 3, 449-66.

35. Plant Disease Section (1924), *Twenty-Third Annual Rept. Philippine Islands Bur. Agri. for the Fiscal Year Ending Dec.* 31, 1923, 159-72. (Received 1925.)

36. Rhind, D. (1924), *Report of the Mycologist, Burma, for the Period Ending 30th June* 1924, *Rangoon,* Supdt., Govt. Print. and Stationery, Burma, 6.
37. Roldan, E. F. (1938), "New or Noteworthy Lower Fungi of the Philippine Islands—II", *Philipp. Jour. Sci.,* 66 (1), 7-13, pl. 4.
38. Saha, J. C. (1945), "Diseases of Rice and Methods for Their Control", *Sci. and Cult.,* 11 (1), 13-20; (2) 69-74, Figs. 3.
39. Savulescu, O. (1938), "Une maladie du riz ricemovent Constatee en Roumanie", *Acad. Roumaine. Bull. Sec. Sci.,* 20 (8-10), 37-38, Illustrated.
40. Sawada, K. (1940), "Rice Blast Disease and Manuring", *Agri. Rept. Formosa,* 35, 22-31; 111-18; 182-89; 251-59; 383-87; 444-49; 655-56. (1937). [Abs. in *Jap. Jour. Bot.,* 10 (4), 62-63 (1940)].
41. Schultz, E. P. (1943), "Las Proximas Siem-bras del Arroz. Con. especial referencial la enfermedad de la 'bruson' *Piricularia oryzæ* (The Next Rice Sowings with Special Reference to the 'Blast' Disease, *Piricularia oryzæ*)", *Circ. Estac. Exp. Agric. Tucuman,* 118, 3.
42. Shimada, S. (1938), "Infectionsweise der Blatter der Reispflanzen durch *Piricularia oryzæ* (The Mode of Infection of the Leaves of Rice Plants by *Piricularia oryzæ*), *Agri. and Hort.* (Japan), 12, 1106-108, Fig. 1. (1937). Japanese [Abs. in *Jap. Jour. of Bot.,* 9 (2), 79.]
43. Small, W. (1922), "Disease of Cereals in Uganda", *Dept. Agri.* Uganda. Cir., 8, 19, Figs. 13.
44. Sueda, H. (1929), "Studies on the Rice 'Blast' Disease", *Rept. Dept. Agri. Govt. Res. Inst. Formosa,* 36, 130, pl. 5, Figs. 3. (1928). Japanese [Abs. in *Jap. Jour. of Bot.,* 4 (3), 73, (1929).]
45. Sundararaman, S. (1927), "Administration Report of the Government Mycologist, Coimbatore, for 1926-27", *Rept. Dept. Agri., Madras Presidency, for the Official Year* 1926-27, 326-44. (1927). (Received October 1928). *Report for* 1928-29, 27 (1929).
46. ——— (1925), "Longevity of Paddy Piricularia", *Year Book, Madras Agri. Dept.,* 1924, 9.
47. Suzuki, H. (1937), "Studies on the Relations between the Anatomical Characters of the Rice Plant and Its Susceptibility to Blast Disease", *J. Coll. Agri. Tokyo,* 24 (3), 181-264, pl. 15, Figs. 6.
48. ——— (1930), "Experimental Studies on the Possibility of Pirmary Infection of *Piricularia oryzæ* and *Ophiobolus miyabeanus* Internal of Rice Seeds", *Ann. Phytopath. Soc. Jap.,* 11 (3), 245-75, pl. 1, Fig. 1. (Japanese with English summary.)
49. ——— (1934), "Studies on an Infection Type of Rice Diseases Analogous to the Flower Infection on *Piricularia oryzæ*", *Br. et. Cav.* Japanese with English summary *Ibid.,* 3 (1), 1-14, Fig. 1.
50. Thomas, K. M. (1940), *Detailed Administration Report of the Mycologist, Madras, for the Year* 1939-40, 18.
51. ——— (1938), *Detailed Admi. Rept. of Govt. Mycologist, Madras, for* 1937-38, 21, Graphs 2.



BLAST DISEASE OF RICE

1. Spores. 2. Infected Paddy Blades. 3. Blasted Panicles.

[*Courtesy : Plant Protection Overseas Review*, 1954, **4**, (3)]

52. Thomas, K. M. (1931), "Some Aspects of the Control of the Blast Disease of Paddy", Reprint from *Madras Agri. Jour.*, 18, (12), 9, pl. 2. [Received January 1931.]
53. *Admin. Rept. of Govt. Mycologist, Madras,* 1936-37, 17, Graph 1.
54. Tisdale, W. T. (1922), "Seedling Blight and Stack Burn of Rice and Hot Water Seed Treatment", *U.S.D.A. Bull.,* 1116, 11, pl. 3, Figs. 2.
55. ——— and Jenkins, I. M. (1921), "Straighthead of Rice and Its Control", *U.S.D.A. Farmers' Bull.,* 1212, 16, Figs. 7.
56. Tochinai, Y. and Shimamura, M. (1932), "Studies on the Physiologic Specialisation in *Piricularia oryzæ", Br. et. Cav. Ann. Phytopath. Soc. Jap.,* 11 (5), 414-41, pl. 2, Graph 1. (Japanese summary.)
57. Tullis, E. C. (1940), "Diseases of Rice", *U.S.D.A. Farmers' Bull.,* 1854, 17, Figs. 14.
58. Tuteffe (1928), "Ein Versuch zur Bekampfung der Fleckenkrankheit des Reises (An Experiment in the Control of the Spot Disease of Rice)", *Zeitschr. Fur. Pflanzenkrankh and Pflanzenschutz,* 38, (9-10), 279-84.
59. Venkatarayan, S. V. (1937), "Report of Work Done in the Mycological Section during 1935-36", *Adm. Rept. Agri. Dept. Mysore,* 1935-36, 51-55.
60. Vincens, F. (1921), "Rapport Sommairo sur les travaux effectues an laboratories de Phytipathologie de l'Institute Scientifique de l'Indo-China du 1 er Janvier 1919 an 1 er Jullet 1921". [Summary of the Work carried out at the Phytopathological Laboratory of the Scientific Institute of Indo-China from January 1, 1919 to July 1, 1921.] *Saigon Imprimerie Commercial,* 19.
61. Wardlaw, C. W. and McGuire, L. P. (1932), "Pitting Disease of Bananas—Its Nature and Control", *Trop. Agri.,* 9 (6), 193-95.
62. Yoshii, H. (1941), "Studies on the Nature of Rice 'Blast' Resistance", *Bull. Sci. Fak. Terk. Kjusu. Univ.,* 9 (3), 277-307. [Japanese with English summary.]
63. ——— (1939), "Some of the Physical and Chemical Differences found in the Inner and Outer Halves of a Leaf-Blade of Rice in Relation to Rice Blast", *Ann. Phytopath. Soc. Jap.,* 9 (2), 93-96, Fig. 1. [Jap. Abs. in *Biol. Abstr.,* 14 (3), 527-28, (1940).]

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GROUNDNUT IN MYSORE

By K. Gopala Iyengar

Excluding U.S.S.R., groundnut is raised over an area of 27·5 million acres in the world. Global production amounts to 9·1 million tons of nuts, in shell. India has 11·3 million acres under this crop, with a production of 3·8 million tons. The share of the Indian Union amounts to 41 per cent. of both the area and production in the world. The area in Mysore is 4,42,833 acres, with a production of 1,27,191 tons ; or nearly 4 per cent. of the area and 4·4 per cent. of the production of the Union. The total area under all oilseed crops in the State is estimated to be 7,07,148 acres, and the production 1,45,000 tons. The share of the groundnut crop amounts to nearly 63 per cent. of the area, and 87 per cent. of the production of all oilseed crops. The First Five-Year Plan has set a target of 1,79,000 tons of all oilseeds to be achieved by the end of 1955-56 season. In the Second Five-Year Plan, this will be increased to 2,05,000 tons, to be achieved by 1960-61.

It is obvious that in concerted measures undertaken to increase the total production of oilseeds in Mysore, major attention has to be devoted to the groundnut crop. The policy laid down by the plans for increasing the production of oilseeds, has always been by intensive cultivation. The measures recommended to be adopted are :

(*i*) Multiplication on a sufficiently large scale, of seeds of higher yielding varieties already evolved and distribution of these on planned basis, so that the entire acreage under oilseeds may be covered by improved varieties ;

(*ii*) Adoption of optimum seed rate and proper spacing by the cultivators ;

(*iii*) Utilisation of manures wherever necessary ;

(*iv*) Controlling of pests and diseases ;

(*v*) Introduction of crop competition schemes.

Improved varieties released in Mysore have been designated by numbers, preceded by the letters H.G. (Hebbal Groundnut). H.G. 1 was one of the earliest improved varieties evolved in India.[3] Distribution of it commenced as early as in 1920, and it occupied several thousand acres in Mysore. In

addition, it also spread to Hyderabad and Madras; being known in the latter State as A.H. 45. Apart from H.G. 1, some quantities of Sugatur, a variant of Mauritius, Virginia and Big Japan, were released for cultivation in earlier years. These were all of spreading habit. In recent years, large quantities of Spanish have been regularly supplied to cultivators from several experimental farms. Issues of such seed during 1952-53, covered an area of 28,589 acres. Recent work, partly financed by the Indian Council of Agricultural Research, and later by the Indian Central Oilseeds Committee, has resulted in the following improved varieties.

TABLE

Variety	Habit	Duration in months	Yield of pods lb. acre	Shelling %	No. of seeds per Kg.	Oil %	Colour of kernel
T.M.V. 3	Spreading	5	624	73	2575	49	Rose
H.G. 7 ..	do	4½	547	74	2908	50	do
T.M.V. 1 control ..	do	4¾	500	72	2564	50	do
H.G. 8 ..	Bunch	4	553	79	2834	50	Red
H.G. 1 ..	do	4	539	78	3068	49	Rose
Spanish control ..	do	4	441	74	3537	48	do
H.G. 10 ..	do	4¾	887	74	1909	49	do
H.G. 1 control ..	do	4¾	674	72	2366	49	do

[*N.B.*—T.M.V. 3 is an improved variety of Madras, and H.G. 9, has been tentatively retained on the approved list, to replace H.G. 8, in case the trade does not favour the red-coloured kernels. H.G. 7, 8 and 10 are under multiplication in a seed distribution scheme partly financed by the Indian Central Oilseeds Committee. Seed to cover 100 acres of "A" seed farms is proposed to be supplied to cultivators in 1956-57. By the close of 1960-61, enough seed to cover 27,124 acres is anticipated to become available.]

The normal seed rate usually employed is 100 lb. per acre of pods. This, generally results in a seed rate of 70-72 lb. of seed in the case of early bunch varieties, and 68-70 lb. for spreading ones. The spacing adopted is 4-6" in the row, and 10-12" between rows. Where seed is of good quality, 50 lb. per acre would prove ample.

This rate is usually employed in parts of Chitaldrug, where the rows are spaced 18" apart. Experiments have

proved that a spacing of 6-9" either way, results in maximum yields.[2] Very close spacing obviously hinders both weeding and intercultivation, except in very early stages. Other measures to be adopted are the use of quality seed, early and clean weeding, and maintenance of a loose mulch to make it easy for the pegs to enter the soil and later develop into pods. Seed from decorticators is to be avoided. Hand-shelled seed always gives more uniform stand and heavier yield. Shell the pods just before sowing, dry the seeds for a day, and sow at once. Kernels with damaged or ruptured seed-coat, results in poor stands and lower yields. Pre-soaking and sowing of just sprouting seeds is often advocated. Unless care is taken to avoid damage to seed-coats, these often result in more harm than good. Above all, sow as early in the season as is practicable. Delayed plantings diminish the yield. A delay of as much as a fortnight, often lower the outturn by 40 per cent.

Manure is not usually applied to groundnuts. The farmyard manure is applied to the food crop that comes in rotation. Trials with farmyard manure have failed to record significant increases in yield, even at the rate of 5 tons per acre. Actual increases in yield obtained often narrowly miss attaining significance. Apart from yield, the application of organic manure has been observed to improve the drought-resistance of the crop. N.P.K. either alone or in different combinations, have resulted in significant increases of yield. The behaviour of N was erratic and generally of no great economic value. P and K have proved beneficial, the benefit being pronounced in the presence of organic manure. A combination of PK has proved to be of maximum benefit.[6] In contrast, Yegna Narayan Aiyer states,[8] "In parts of the black cotton soil tracts, notably round Davangere in the Mysore State, the use of artificial manures for groundnuts has become popular. A mixture of 1 cwt. of sulphate of ammonia and 1 cwt. of superphosphate per acre are drilled into the furrows at sowing time along with the seeds, the manure being drilled in the one furrow seed-drill or *sadde*. Groundnuts respond well to such manuring and heavier doses could be used with advantage if it were not that insufficient rainfall may make it infructuous or possibly even harmful. Where it is grown under irrigation, higher doses may safely be applied with advantage. The response to lime has been reported early.[2] Recent findings have demonstrated the value of superphosphate applied along with lime."[7]

The mining caterpillars *Stomopteryx nerteria* Mevr. or sural is the major pest. The incidence often becomes epidemic, causing serious losses. As soon as leaves are first observed to curl up, the plants should be dusted thoroughly with a mixture of Gammexane and fine wood ash or chalk powder (1 in 6 parts). Light traps in the field will attract the adult moths. All curled and withered leaves should be collected and burnt.[1] Aphis has begun to cause appreciable damage to the crop, particularly in the arid northern part of the States. The aphid *Aphis laburni* Kalt. can be controlled by periodical application of BHC 5 per cent.[4] The red-headed hairy caterpillar, *Amsacta albistriga* Walker, often migrates on to groundnut from adjacent crop of ragi or jola. This causes considerable defoliation and total loss of young crop sometimes occurs. Light trap will trap the adult moths. These can also be collected by hand and dropped into a vessel containing kerosined water. Leaf-spot or *tikka* caused by a species of *Cercospora* often causes 30-50 per cent. loss in yield. Spraying with Bordeaux mixture results in partial control. Seeds soaked in formalin water 1 : 400 for 4 hours, or in a copper sulphate solution of 0·5 per cent. strength for ½ hr. result in some measure of control. Root-rot due to a species of *Sclerotium* often causes wilting and death of plants.[1] Another disease due to a virus *Rosette,* causes a dwarfing of the plants and a crowding or shortening of the leaves. Mosaic on leaves is sometimes noticed. Wilt, caused by a species of *Rhizoctonia,* occurs in a sporadic form when the crop is raised under irrigation. It has been reported from Madras that H.G. 1 has recorded consistently low infection.

Crop competitions no doubt serve a purpose in stimulating production. It is proposed to organise such competitions for groundnut, on the same lines as is being done in the case of paddy, ragi and potato.

The two Five-Year Plans postulate that production should be increased, without any undue expansion of the area. The area under groundnuts in the State is continually expanding, and if the present trend continues, it may be expected to reach 0·55 million acres by 1960-61. The yields per acre have to be increased from 0·28 ton to 0·35 ton. In conclusion, the salient measures required to be adopted to achieve the target set, are—

(*a*) Raise improved varieties, as seed is released from the Department of Agriculture.

(*b*) Prepare a clean seed-bed, sow quality seed, and sow as early as possible in the season.

(*c*) Space plants, 9″ × 9″ square or in rows 10-12″ apart and 6″ in the row or 4″ in the row in rows 18″ apart.

(*d*) Try to apply per acre, farmyard manure or compost 1 ton, superphosphate 1 cwt., muriate of potash 90 lb. and lime 100 lb.

(*e*) Weed as early as possible, and as often as required.

(*f*) Employ remedial measures to keep down pests and diseases in time.

(*g*) Harvest only when the crop is completely ripe and dry the pods well before disposal or storage.

References

Anon (1949), "Measures of Prevention and Control against Some Important Pests and Plant Diseases of Crops", *Bull. Dept. Agric. Mysore,* **22**, Bangalore.

Badami, V. K. (1931), "Groundnut in Mysore", *J. Mysore Agric. Expt. Union,* **11**.

——— (1939), "Improvement of Crops in Mysore", *l. c.,* v7.

Channa Basavanna, G. P. (1954), "Insect Pests of Some Cash Crops", *Mysore Agric. Calendar and Year-Book,* 1954.

Gopala Iyengar, K. (1954), "Groundnut Breeding in Mysore", *Mysore Agric. J.,* **30**.

Venkata Rao, B. V. and Govinda Rajan, S. V. (1954), "Effect of Lime and Phosphate on Yield and Pod-Filling of Groundnut", *Ibid.,* **30** (in print).

Subbiah, M. (1936), "A Short Note on Groundnut Manurial Experiments on the Irwin Canal Farm, Mandya", *J. Mysore Agric. Expt. Union,* **16**.

Yegna Narayan Aiyer, A. K. (1944), *Field Crops of India,* Bangalore.

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MYSORE DACINÆ AND THEIR NATURAL PARASITES

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Introduction

Mysore State has for many years been a favourite collecting ground for fruit-flies and their natural parasites, and a number of specimens have been taken from within its boundaries. During the past half-a-century no less than five foreign missions—‡Compere in 1907, Silvestri in 1909, Fullaway in 1915, Gurney in 1935, and Bianci, Beevor and Lawrence in 1950—visited Bangalore to investigate the parasitism of the fruit-flies and collected whatever natural enemies could be discovered, the outstanding species being *Syntomosphyrum indicum* Silvestri, the fruit-fly parasite which was introduced into Australia, the Cape, Italy and New South Wales, and *Bracon* (= *Opius*) *fletcheri* Silvestri, which was introduced into Hawaii (Fullaway, 1920; Gurney, 1936; and Clancy *et al.*, 1952). A record of the Dacinæ, which are the common fruit-flies occurring in Mysore State, and their natural parasites is, therefore, of considerable interest. Because the true Dacinæ are distributed in the Tropics and the Sub-Tropics, the home of some important species like *Dacus cucurbitæ* Coquillet being known to be India (Bezzi, 1913), and in the absence of complete data concerning the depredations of this pest in this country, there appears to be an impression that the fruit-flies are not a serious pest here, perhaps being kept effectively under check by their natural para-

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‡ Compere, George. Jointly employed by the Australian States and the State of California.

Silvestri, Filippo. An Italian Entomologist visited on behalf of Hawaiian Islands.

Fullaway, D. T., Entomologist, Hawaiian Islands.

Gurney, Wm. B., Entomologist, New South Wales, financed by the Fruit Growers' Federation of N.S.W. and the Commonwealth Bank.

Bianci, F. A. and party. On behalf of United States Department of Agriculture, Bianci representing the Territorial Board of Agriculture and Forestry, Hawaii.

sites. The actual position is, however, quite different. Fruit-flies are a serious pest and some of the species are very destructive, for example, *Dacus dorsalis* Hendel, *D. ferrugineus* Fabricius and *D. zonatus* Saunders inflict severe losses on mango, guava and peaches in most years, and due to damage by *D. cucurbitæ* the entire crop of watermelons, cucumbers, etc., is lost in certain years, while in others a reduction in the quantity of harvested fruits occurs. Although 21 different natural parasites have recently come to light, the extent of parasitisation of the fruit-flies does not exceed 3·13 per cent.

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Fruit-Flies and Their Host Range, Distribution, Seasonal Occurrence and Natural Parasites

Family Trypetidæ (Trypaneidæ)
Subfamily Dacinæ
Genus Dacus Fabricius

In Mysore State the subfamily Dacinæ is represented by this single genus.

D. bipustulatus Bezzi. Arabidacool and Santaveri coffee estates, Chikmagalur District; March to April and also in October. Though this species was taken twice, its host has not been recorded. The specimens from Arabidacool furnished the material for Bezzi's (1914-15) description of this species.

D. caudatus Fabricius. Bababuddin Hills and Hirekan coffee estate, Chikmagalur District; November and December. Host not on record.

D. ciliatus (Loew.). Bangalore and Hagari, Bellary District; musk melon (*Cucumis melo*), water melon (*Citrullus vulgaris*) and *Cephalandra indica* (Cucurbitæ); April to December.

Parasites.—*Opius incisi* Silvestri, *Spalangia philippiensis* Fullaway, *S. afra* Silvestri, *S. stomyoxysine* Girault and *S. gro-*

tiusi Girault, *Dirhinus giffardii* Silvestri, *D. luzonensis* Rohwer, *Pachycrepodeus dubius* Ashmaed and *Galesus* spp. The percentage of parasitisation was very low, and from among the various parasites *Dirhinus* spp. were more abundant. All the parasites emerged from the puparia of *D. ciliatus* infesting *Cephalandra indica*, but none from those in other host plants.

D. correctus Bezzi. Bangalore and Balehonnur; Ber (*Zizyphus jujuba*), mango (*Mangifera indica*), rose apple (*Eugenia Jambos*), *E. michelli*, guavas (*Psidium Gujava*), sandal berries (*Santalam album*) and *Coffea robusta*; March to May and November to December. It was also taken on castor leaf in Hagari, Bellary District.

Only a solitary *Dirhinus* sp. was obtained from a puparium of *D. correctus* infesting rose apple.

D. cucurbitæ Coquillet. By far the most destructive species to cucurbits in certain areas. In Bangalore it has been taken on the snakegourd (*Trichosanthes anguina*), bittergourd (*Momordica charantia*), water melon (*Citrullus vulgaris*), cucumber (*Cucumis sativus*), *Cephalandra indica* and a wild vine with red drupes. Male flies are attracted to methyl eugenol.

Parasites.—Pachycrepodeus dubius, Dirhinus giffardii, D. luzonensis, Spalangia philippiensis, S. afra, S. stomyoxysine, S. grotiusi and *Bracon fletcheri* Silvestri. *B. fletcheri* was the important species collected by Fullaway in Bangalore and introduced into Hawaiian Islands for the successful control of the melon fly (Fullaway, 1920).

D. diversus Coquillet. Bangalore and Malagar coffee estate, Chikmagalur District; Honde fruits (*Cerbera manghas*), guavas, wild mangoes and wild nutmeg; May to December.

D. dorsalis Hendel. This is the most important species, which along with *D. ferrugineus* and *D. zonatus*, infests mango causing substantial damage in most years. Occurs throughout Mysore State. Hosts include mango (*Mangifera indica*), *Solanum auriculatum, Solanum* sp. and orange (*Citrus nobilis*). Male flies are attracted to citronella oil and methyl eugenol.

Parasites.—Opius persulcatus Silvestri, *O. oophilus, O. compensans, O. incisi, O. manii, Syntomosphyrum indicum* Silvestri, *Spalangia philippiensis, S. afra, S. stomyoxysine, S. grotiusi, Dirhinus giffardii*, and *D. luzonensis, Pachycrepodeus dubius, Trichopria* sp., *Trybliographa daci* Weld, *Pseudeucoila* spp., *Cothonaspis* spp. and *Galesus* spp. Although as many as 20 different pupal parasites occur in nature, the total parasitisation is not more than about 5 per cent. during June to December. Among the various parasites *S. indicum* is the most abundant species (being 65·5 per cent. of the total parasite population) and *O. persulcatus* and *O. oophilus* come next (the two species together accounting for 23·2 per cent. of the parasite population), while *Pachycrepodeus dubius,*

Spalangia spp., *O. compensans* and *Trichopria* sp. are present in very small numbers and the remaining species occur as stray cases.

D. ferrugineus Fabricius. As already stated this species along with *D. dorsalis* and *D. zonatus*, is the common fruit-fly causing substantial damage to mango and guava throughout Mysore State. In addition, it infests honde fruits (*Cerbera manghas*), *Solanum rubustifolium*, *Solanum* sp. and sandal berries. Male flies are attracted to very dilute citronella oil and methyl eugenol.

Parasites.—*Syntomosphyrum indicum* and *Opius persulcatus* were obtained from the pupæ of *D. ferrugineus* infesting mango. *S. indicum* were collected, reared and imported into New South Wales by Gurney (1936) from puparia of *D. ferrugineus* infesting guava, *Solanum rubustifolium* and some wild fruits.

D. incisus Walker. Bangalore and Balehonnur ; sandal berries, guava, orange (*Citrus nobilis*), cucurbits, Ficus sp. and *Coffea robusta* ; also noticed on mango leaves. March to December.

Parasites.—*Opius persulcatus, O. oophilus, O. compensans, O. incisi, Syntomosphyrum indicum, Spalangia* spp., *Dirhinus giffardii, D. luzonensis, Pachycrepodeus dubius, Trichopria* sp., *Trybliographa daci, Pseudeucoila* spp. and *Cothonaspis* spp. Though there are 15 different parasites, the total parasitisation of *D. incisus* did not exceed 0·8 per cent. during the period March to December. *Dirhinus* spp. and the Cynipidæ were the more common species, *Pachycrepodeus dubius* and *Opius persulcatus* being less so, while the remaining species occurred rarely.

D. latifrons. Bangalore ; *Solanum sisymbrifolium, Solanum* sp. and mixed cucurbits, which included snakegourd, cucumbers, etc., March to May.

Parasites.—*Dirhinus giffardii* and *D. luzonensis* were obtained in small numbers, and stray cases of *Opius persulcatus, O. oophilus, Spalangia* spp. and *Pachycrepodeus dubius* were noticed. All these parasites were collected from the puparia of *D. latifrons* infesting *Solanum sisymbrifolium* and *Solanum* sp., but none from the fruit-flies in Cucurbitaceous hosts.

D. (= *Leptoxyda*) *longistylus* Wiedmann. Bangalore and Pura, Hassan District ; *Calotropis gigantea* ; July.

D. migrotibialis Balehonnur. *Coffea robusta* ; March.

D. nubilis. Bangalore ; *Cephalandra indica* ; May to December.

D. scutellaris Bezzi. Yemmekan coffee estate, Chikmagalur District ; host not recorded.

D. scutellarius Bezzi. Goorgahalli coffee estate, Hassan District ; host not recorded ; March. A solitary specimen of this species

was obtained which furnished the material for Bezzi's (1916-17) description of this species.

D. zonatus Saunders. Bangalore and Santaveri. A common pest of mango throughout Mysore State ; this species is predominant particularly in Srinivaspur, Kolar District. In addition to mango, it infests peaches causing considerable damage in some years, and also Hadgad fruits. March to May. Male flies are attracted to dilute citronella oil and methyl eugenol.

Opius (= *Austroopius*) sp. has been recorded as a pupal parasite of *D. zonatus* infesting mango (Ayyar, 1920).

Dacus sp. Bangalore ; host not recorded ; July.

Opius longicaudatus (Ashmaed) was obtained from the puparium.

Summary

In Mysore State the subfamily Dacinæ is represented by the single genus *Dacus* Fabricius and the following 17 species : *bipustulatus* Bezzi, *caudatus* Fabricius, *ciliatus* (Loew), *correctus* Bezzi, *cucurbitæ* Coquillet, *diversus* Coquillet, *dorsalis* Hendel, *ferrugineus* Fabricius, *incisi* Walker, *latifrons, longistylus* Wiedmann, *migrotibialis, nubilus, scutellaris* Bezzi, *scutellarius* Bezzi, *zonatus* Saunders and *Dacus* sp. They occur throughout the year and infest many cultivated and wild plants, chief among the former being mango, guava, peach, Cucurbits like watermelon, cucumber, gourds, *Cephalandra indica,* etc., rose apple and *Coffea robusta* ; sandal berries in a wild state are commonly attacked.

Twenty-one Hymenopterous parasites were obtained. They were :

Braconidæ : *Bracon fletcheri* Silvestri, *Opius persulcatus* Silvestri, *O. oophilus, O. incisi* Silvestri, *O. longicaudatus* Ashmaed and *O. manii* and *Opius* (= *Astroopius*) sp.;

Pteromalidæ : *Pachycrepodeus dubius* Ashmaed ;

Spalangiidæ : *Spalangia philippiensis* Fullaway, *S. afra* Silvestri, *S. stomyoxysine* Girault and *S. grotiusi* Girault;

Chalcididæ : *Dirhinus giffardii* Silvestri and *D. luzonensis* Rohwer ;

Diapriidæ : *Galesus* spp. and *Trichopria* sp.; and

Cynipidæ : *Trybliographa daci* Weld, *Pseudeucoila* spp. and *Cothonaspis* spp.

All these are pupal or larval-pupal parasites. Although a fairly large number of parasites was recovered, the extent of natural parasitisation was very low, being only 3·13 per cent.

References

Ayyar, T. V. R. (1920), "On the Insect Parasites of Some South Indian Crop Pests", *Rep. Proc. III Ento. Mtg., Pusa,* 3 : 931-36.

Bezzi, M. (1913), "Indian Trypaneids (Fruit-flies) in the Collection of the Indian Museum, Calcutta", *Mem. Indian Mus.,* 3 : 51-175 (Abstr.).

——— (1914-15), "Two New Species of Fruit-Flies from Southern India", *Bull. ent. Res.,* 5, 153-54.

——— (1916-17), "On the Fruit-Flies of the Genus Dacus (*s. l.*) Occurring in India, Burma and Ceylon", *Bull. ent. Res.,* 7, 99-121.

Clancy, D. W., Marucci, P. E. and Dresner, E. (1952), "Importation of Natural Enemies to Control the Oriental Fruit-Fly in Hawaii", *J. econ. Ent.,* 45 (1): 85-90.

Fullaway, D. T. (1920), "Control of the Melon-Fly in Hawaii by a Parasite Introduced from India", *Rep. Proc. III Ento. Mtg., Pusa,* 2 : 625-29.

Gurney, W. B. (1936), "In Search of Fruit-Fly Parasites in India—A Summary of Investigations made in 1935", *Agric. Gaz. N. S. W.,* 47, 374-78 (July 1, 1936).

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CULTIVATION OF GARLIC IN MYSORE

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Garlic (*Allium sativum* L.), a bulbus crop, belonging to the natural order Liliaceæ to which onion, leek, shallot, etc., belong, is a temperate zone crop. Mediterranean countries seem to be the home of this crop, though some are of opinion that South-West Siberia or Central Asia is its natural home. It is a vegetable of great antiquity. Earliest reference about this crop is found in Egyptian literature as far back as 4000 B.C. The Romans and the Greeks knew of the many uses of this crop and cultivated it intensively long before Christ. It is from these countries that the crop must have spread to other European and Asiatic countries and even to the new world. As an article of diet it is principally used for spicing and flavour. It is also of great medicinal value and is freely used in all *Ayurvedic* and *Unani* medicines.

In India, the crop was under cultivation long before Alexander the Great stepped on Indian soils. It is now grown in all States in India but only in small patches and rarely on field-scale. The needs of the locality is the prime consideration in regulating the extent of land there, under this crop. There was a marked increase in the acreage under this crop in almost all Provinces and States in India during war years ; but it has now reverted to normal. Northern India and Deccan tracts produce over 80 per cent. of the crop in India. South India and Mysore have comparatively small acreage.

Area under Garlic

In Mysore the crop is normally grown over an extent of 3,000 to 4,000 acres. During war years, it rose considerably and was of the order of 6,000 to 7,000 acres. But now, it has reverted back to normal acreage of 3,000 to 4,000 acres. It is difficult to get the exact acreage figures for this crop as it is rarely grown on more than $\frac{1}{4}$ acre on individual holdings. In majority of cases it is about 4 to 6 *guntas* and moreover garlic is very often grown in association with other crops like onion, leafy vegetables or brinjals, or garlic itself is grown as a subordinate crop, as in some of the coconut gardens in Kadur and Banavar areas or in plantation gardens as in Bellary area.

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The following table will indicate the approximate distribution of this crop in the several districts of the State as given in the season and crops report.

Acreage under garlic in the different districts of Mysore State from 1938-39 to 1952-53

District	1938-39	1939-40	1940-41	1941-42	1942-43	1943-44	1951-52	1952-53
Bangalore ..	214	260	162	280	326	317	107	96
Kolar ..	190	171	191	233	353	343	349	421
Tumkur ..	..	..	..	..	..	..	49	53
Mandya ..	80	201	194	138	129	175	175	431
Mysore ..	24	21	14	33	12	25	..	..
Hassan ..	..	..	..	..	..	..	1206	1076
Chikmagalur ..	3959	3946	2846	2929	3031	2768	2456	744
Shimoga ..	59	55	38	26	27	20	12	38
Chitaldrug ..	..	..	..	..	..	..	92	73

Acreage figures for Hassan, Chitaldrug and Tumkur for war years are not available in the season and crop report; even the marketing report does not make any mention about the acreage in those districts though Hassan was having a fairly large acreage from a long time and must have got significantly increased during war years. From enquiries it is found that Hassan alone had nearly 2,000 acres during war years, *i.e.*, 1940 to 1946. In Chitaldrug it was about 250 to 300 acres and in Tumkur it was about 75 to 100 acres. The acreage for these districts have either got merged with those of onion in those districts or got included under the column "others" under the 'spices' in the season and crop report. Chikmagalur and Hassan Districts produce more than two-thirds of the crop of the State. Kadur and Hassan Taluks produce nearly half the crop of the State. Doddaballapur and Devanahalli produce more than 60 per cent. of the crop in Bangalore District. Chikkaballapur, Sidlaghatta and Kolar produce more than 80 per cent. of the crop in Kolar District. Malavalli and Krishnarajapet produce more than 80 per cent. of the crop in Mandya District. Hassan and Arsikere produce more than 90 per cent. of the crop in Hassan District; Kadur and Chikmagalur produce more than 98 per cent. of the crop in Chikmagalur District. Kadur Taluk having an area of 2,000 to 3,000 acres leads the rest in the State and is followed by Hassan Taluk having an area of 1,200 to 1,500 acres.

From the analysis of the acreage figures, it is easy to infer that the crop grows well in dry tracts. It is practically absent in the heavy rainfall tracts and it is a crop of the plains.

Soil adopted for growing onions, as a rule, produce good garlic. Garlic grows on a variety of soils depending upon the season and method of cultivation. As a *hingar* dry crop, it grows in the black cotton soil and as a *mungar* dry crop it grows on sandy or sandy loam, as is found in the coconut gardens of Kadur and Banavar areas. As an irrigated crop it grows on clay to clay loam soils under several tanks both in *mungar* and *hingar* season. Loam to clay loams with adequate quantity of organic matter, iron and lime and soils having good drainage are by far the best soils for garlic. More than the soil, it is the handling of the soil that matters.

Garlic grows under a fairly dry and cool climate at an altitude of 2,000-3,000′ where facilities for irrigation exist ; rainfall is of no consideration. In fact, it is mostly an irrigated crop. It is best grown during the cold months though under Mysore conditions they do take a summer crop. Garlic growing areas receive a rainfall of about 25-35″ and have a temperature range of 50-75° F., during the growth and bulb formation periods. In addition it needs a clear sunny weather. Dew fall is good but fog and mist are bad.

Botany of the Crop and Seed Material

Garlic is a liliaceous bulb crop. The leaves like those of the onion are two ranked and have sheathing bases. The two plants differ most obviously in the shape of leaf-blades and in the storage structure of the bulb. The leaf-blade of onion is round in cross-section and hollow. Those of garlic are flat and slightly keeled. The outer layers of the mature garlic bulb are formed of the thin dry sheathing bases of the foliage leaves as in the onions. If these dry sheaths are successively removed from the garlic bulb, a sheath is finally reached which not only surrounds the remainder of the bulb as in the case of onions but also bears in its axils a storage bud which is absent in onions. Such a storage bud is commonly called a 'clove' or a bulblet. The term "clove" is most frequently used for the storage buds after they have been separated from the mother bulb. For this reason the portion of the bud stem which remains with the mother bulb is not considered as a part of the clove. Cloves themselves are actually small bulbs but to conform to well established common terms, bulb will be applied only to the large compound storage structure of the whole garlic plant.

One or more cloves will be found in the axil of each successive sheath progressing towards the centre of the bulb. Ten

to twelve sterile leaf-sheaths, *i.e.*, leaves that bear no cloves in their axils are usually found on the outside of the mature garlic bulbs. Some of them may be lost during growth and harvesting. A typical garlic bulb may have a dozen outer sterile leaves of which half are lost in growth and handling and within these 6 to 8 clove bearing leaves there will be 10 to 20 cloves. Cloves constitute 95 per cent. of the bulb by weight.

Garlic clove when it begins to sprout is seen to have a protective sheath which surrounds the cloves and from the stem produces several adventitious roots. Many of these roots which are produced abundantly and quickly when mature non-dormant cloves are planted in moist soil are initiated while the clove is still growing on the mother bulb. According to certain authorities an average mature clove possesses about 20-40 well developed but un-elongated roots. Even before planting some of them penetrate completely through the thick base of the storage leaf but most of them are still embedded. Usually cloves of a bulb, except those near the centre are quite asymmetrical and most of the roots develop on lower side. Cloves on the outer side are bigger than those in the centre and make better planting material. Garlic is seen to flower occasionally. Seed stalk in garlic develops from the tip of the main stem, terminating further vegetative growth. The seed stalk is often seen to bear a cluster of bulbs or bulbels in the inflorescence. Flowers are usually mixed among the top sets though at times they may be small and inconspicuous. The flowers are apparently sterile and so true seed of garlic is more or less unknown. Plants producing seed stalks also produce a bulb with cloves, at ground level. Seeders are commercially undesirable as it is believed to be associated with low yields though it is not always so and such a fear is unfounded. Garlic is a true perennial and will keep on producing bulblets while onion is short-lived and must come up again from seed.

Types of Garlic

Types of garlic are found to vary in regard to colour, size of the bulb, sheath and cloves. Writers on garlic mention two distinct forms of garlic. One has broader leaves, green tops, short stem, larger cloves which do not keep well in storage, *e.g.*, Calcutta or Nilgiri type. The second type has a comparatively narrow, pale leaves producing smaller bulbs and cloves of excellent keeping quality. This type matures very early. The Mysore varieties fall under the second group. Three Russian

types known as Donbas garlics are becoming popular. They are Ukranian, Mauve Zampole and Straboljick.

The varieties grown in Mysore are either white, also called Bombay garlic or the other pinkish or Hassan type. A sport from the white is the Thirupathy which is like the Bombay type ; the only difference is that the cloves of Bombay type are fig-shaped while those of Thirupathy are ridged. Eighty to eighty-five per cent. of Mysore garlic is pink type, 10-15 per cent. Bombay type, and just 2-3 per cent. forms the Thirupathy type. Calcutta or Nilgiris is not popular and is not under cultivation anywhere in Mysore excepting in some of the vegetable gardens near Bangalore where it is grown along with leafy vegetables, etc. The white type is grown in Chitaldrug District both as a dry and as an irrigated crop on black cotton soils. The bulbs and cloves of this type are hard, medium to big in size, with their green tops rarely putting forth the seed stalks. They are very pungent and emit strong odour. The odour is nearly akin to asafoetida. It has good keeping quality. It does not sprout in the field even if there is some delay in harvesting of the crop. It is a heavy yielder. The pink or the Mysore local type is largely grown in Kadur, Hassan, Arsikere and Chikmagalur areas, *i.e.*, in the principal garlic growing areas of the State as an irrigated crop under tanks and wells. This variety produces uniform and medium type of bulbs having 12-16 cloves. It occasionally produces seed stalks and bulbels too. The cloves are small and hard and like the Bombay type have great keeping quality. It matures earlier than Bombay taking hardly 3½-4 months. It grows on all light-coloured soils. It yields fairly high even up to 300 md. per acre though the average yield may be hardly 60-100 md. It is less pungent than the Bombay garlic and emits an odour which is somewhat midway between asafoetida and onion. The cloves of this variety start sprouting in cases of delayed harvest or even when the crop is growing. Calcutta or the Nilgiris produce big bulbs and four or five big cloves. It has no keeping quality. The smell is not quite agreeable. It makes its appearance in the Bangalore market when stocks of the local variety has run down. In Bellary, two varieties are found growing *Jawari gedde* early-maturing type taking 4 months, (2) *Rajalle gedde* taking 5 months, having larger bulbs and cloves and yielding about 4,000 lb. per acre. Another variety from South India is *Mallipoodu,* a heavy-yielding type. It has done very well even in Ceylon and America.

Seed Material

Garlic bulbs as described above is a compound bulb made up of leaf-sheaths, bulblets, etc. Bulbels or cloves (ಬೀಜ, ಉಲಗು, ಇನಕು, ತಿರಿ) as popularly known in the local language, form the chief seed material for further propagation; though bulbs and bulbels may also be used for propagation purposes. A few trials, conducted on the Hebbal Farm a decade ago, to find out the possibility of using bulbels as seed material, have given fairly encouraging results. In some of the American States they use the entire bulbs for planting giving wider spacing. Even there, in general practice, cloves alone form the planting material. For this purpose, carefully selected mature good-sized bulbs are collected at the time of harvest. They are sun-dried for 2 or 3 days. All the loose sheaths are removed, roots trimmed and are tied into bunches or plaited by braiding the tops and hung on pole close to the ceiling of one's house or hung in a dry and well ventilated place where they remain for over 2 months.

Seed bulbs should be from disease-free fields. Bulbs from one season will provide seed material for the next season, *i.e.*, bulbs harvested during August are fit enough for providing seed material for planting in October-November as the case may be, after a rest of about 2 months.

A few days before planting they are lowered and exposed to the sun for a day or two. The bulbs are crushed and the hard cloves are separated. The bulbs are actually trampled under feet to free the cloves from the adhering sheaths. They are then winnowed to separate the heavy and well developed cloves from under-developed ones and the sheaths. The seed material is thus got ready for sowing.

Sometimes they sprout the cloves before sowing. This is done by merely heaping the bulbs on the floor and covering the same with paddy straw or gunny cloth. They sprout in a fortnight's time. These sprouted cloves are dibbled in prepared fields or beds. Ordinarily 6-8 md. of garlic bulbs give enough cloves to go for 1 acre. Cloves on the exterior of the bulbs form better planting material than those from the interior. Bigger-sized cloves for the same variety give better crop than the medium and small.

Rotation on Drylands

Garlic is rotated with common dryland crops like *hingar* jola, bengalgram or cotton in black soil areas,

and with greengram, blackgram, horsegram or chillies or even a *hain* crop of transplanted ragi in red soil areas. Under tanks it is usually rotated with paddy. *Vaishaka* garlic is rotated with *Karthika* paddy or *vice versa*. Where two crops of garlic are taken in the same year, on the same land, after every two or three years a crop or two of paddy is taken and is followed again by garlic. Garlic is generally a pure crop but sometimes a row or two of onion, *navane** or chillies is grown on the border of garlic beds, or garlic may be a mixed crop with onions, leafy vegetables, raddish or carrot and sown in beds by broadcasting. In Bellary District much garlic is raised in rotation with paddy and sugarcane and also as an inter-crop in young plantains.

Cultivation

Garlic receives a thorough cultivation both as a dry and irrigated crop. It is taken both as a *mungar* (S. W. Monsoon) and *hingar* (N. E. Monsoon) crop. *Mungar* irrigated crop is planted during *Bharani* and *Krithika* rains, *i.e.,* end of April to middle of May, while the *mungar* dry crop is planted during *Aridra* and *Punarvasu, i.e.,* the end of June to the middle of July. Similarly *hingar* irrigated crop is planted during *Anuradha* and *Jyeshta, i.e.,* the end of November to middle of December, while *hingar* dry crop is planted during *Chitta* and *Swathi* rains, *i.e.,* the month of October. Time of commencement of preparatory cultivation is regulated according to sowing or planting time. Sixty to seventy per cent. of the crop is during *hingar* months and about 30-40 per cent. during *mungar* months. Garlic like onion is a great soil cleaner and has a property of killing all harmful bacteria. A new type of antibacterial principle was isolated from the cloves of garlic. This substance is *allisin* which is a colourless oil, approximately 2·5 per cent. soluble in water and relatively unstable. Its antibacterial action was demonstrated against gram positive and gram negative bacteria.

Cultivation of Dry Crop of Garlic.—Though garlic is mostly an irrigated crop, still about 10-15 per cent. of the crop is grown as a dry crop. This is particularly so in the black cotton soils, during *hingar* months and in the coconut gardens during *mungar* months. In the black cotton soil tracts, both in and outside Mysore, garlic is raised as a dry crop. During the rainy months the land is repeatedly

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* *Setaria italica* ; *Hain* = Late season ; *Vaishaka* = Summer ; *Karthika* = Autumn.

harrowed to conserve soil moisture and to remove weeds and stubbles. The land is thus brought to fine tilth. During *Chitta* and the following rains, *i.e.,* in October sowing of garlic is taken up. Sowing is done in plough furrows either through *sadde* (a single-tyned drill) or directly by dropping the cloves in plough furrows. Big and heavy cloves from big-sized white garlic bulbs are used for sowing. About 6 md. of bulbs are required to serve as seed material for 1 acre. These bulbs are crushed and individual cloves are separated, which are then used for sowing. The cloves germinate and come up above the ground in about a fortnight's time. The inter-space between garlic is hoed three or four times during the first ten weeks of the crop. The crop is also hand-weeded once. The crop matures in about 4 months time when it is pulled out either by hand or with the help of *guddalies* (hand hoes). As the crop matures the bulbs get lifted above the ground and the tops turn yellow and start withering. After the crop is pulled out it is allowed to remain in the field for a couple of days. They are spread thinly and uniformly along the rows. They are then gathered and carted to the dwelling quarters for further handling. Yield is about six times the seed-rate. While this is so in black soil tracts, in the coconut gardens of Kadur and Banavar where the soil is sandy to sandy loam, garlic is taken as an inter-crop. The inter-space between coconut palms is ploughed 4-6 times and harrowed. A log harrow is worked to break the clods. Beds of $2' \times 2'$ or $4' \times 4'$ are made. These beds are manured at about 10 cartloads of compost per acre. After a soaking rain, garlic cloves are broadcasted in these beds and raked up. After the cloves germinate, which they do in about two weeks' time, hand-weeding is done and the soil is mulched. The crop matures in about $3\frac{1}{2}$-4 months' time when it is pulled out or dug out and handled in the same manner as stated above. The seed rate is about 8 md. of bulb and the yield is five times.

Cultivation of Garlic as an Irrigated Crop.—Nearly 85-90 per cent. of the crop is under irrigation either from tanks or wells, mostly the former. Though the crop does not require much water for growth and maturity, still it needs well regulated supply. The crop is raised in both the seasons either in the *mungar* or *hingar*. Sometimes two crops of garlic are taken one after another on the same land, in the same year, one in the *mungar* and the other in the *hingar* season.

Cultivation under Tanks.—Soils are generally clay loam to clay, *i.e.,* soils are generally heavy in nature. Preparatory culti-

vation operations commence about two months before planting and they consist of ploughing the land half a dozen times with the country plough or twice or thrice with the improved plough and is followed by *Hegga kunte* or a cultivator. If the land is too hard for cultivation it is splash irrigated and when it is in a workable condition it is ploughed. Where the holdings are small they resort to digging, in which case it is dug twice or thrice. The first digging is to a depth of about 1′ and after thorough weathering, a second digging to a depth of about 6-8″ is given and is followed by a third one which is more in the nature of stirring the land to facilitate formation of bed. During the course of digging or ploughing and harrowing, stubbles of the previous crop, if any, are removed and the land is levelled. Sometimes a log harrow is worked to level the land, smoothen the surface and to create a fine seed-bed. The field is manured and laid into beds or laid into long strips according to local practice. In parts of Chitaldrug District the fields are laid into long strips of 4½-6′ in width with the help of the head piece of the blade harrow or these beds may even be formed with a small bund former. Garlic is sown in bed and onion or *navane* on the ridges. In parts of Hassan District, after the preliminary preparations of the land are over, the fields are laid into long strips 5½′ in width intercepted by drains or trenches called *Pari*. These *paris* are meant to allow excess rain water to flow out and to prevent water-logging or soil erosion. In Doddaballapur and Sidlaghatta, after preliminary preparation of the land is over, garlic cloves are broadcasted and then the field is divided into long strips by opening plough furrows at 6″ apart. Trenches are dug all round the field to secure proper drainage.

Garlic Cultivation under Wells.—Soils are generally sandy loam to loam in nature. Cultivation is more intensive than under tanks. Most of the operations are done by manual labour. The field is hand-dug twice or thrice ; clods are broken and the land is levelled and laid into long strips of about 8-12′ width. Between two strips a water channel is made. These strips are manured with town sweepings at about 10 cartloads per acre. In the absence of city or town sweepings double the quantity of farm compost is applied. Manure is spread and beds 2′ × 2′ are made. Sometimes manuring is done after the formation of beds. The beds are splash-irrigated and cloves of garlic are dibbled. Seed rate for a winter crop is about 25-30 md. of garlic bulbs. The distance between cloves is 2-3″. The seed rate

for the summer crop, which is a mixture of several other crops such as coriander, radish, carrot, leafy vegetable, etc., is very low and is about 6 md. of bulbs. Other aspects of cultivation are the same as under tanks. The yield is about 100-150 md. to an acre for the winter crop and 40-60 md. for the summer.

Manuring

Farmyard manure is the only manure that garlic growers are accustomed to use. In Chitaldrug it is about 6-8 tons of farmyard manure. In Chikkaballapur, Sidlaghatta and Doddaballapur, they apply about 20-30 cartloads (about 10-15 tons), while in Hassan and Kadur they apply 10-15 cartloads together with 40-50 cartloads of silt and red earth. Sheep folding is also sometimes practised in these areas. Use of artificials is not usually met with. It is only in recent years that a few garlic growers in Chikkaballapur, Doddaballapur, Davangere and such other places have resorted to the use of artificials consisting of a mixture of ammonium sulphate and superphosphate. They use about 200-300 lb. of the mixture. A proper type of artificial should, it is said, contain 4 parts of N, 10 parts of P_2O_5 and 4-6 parts of K_2O and about 400-500 lb. of the mixture should be applied with a basal dose of 7-8 tons of compost. In some of the American States they use even 1,000 lb. of the above mixture and harvest over 6 tons of garlic. Nitrogen may be as Am_2SO_4 alone or groundnut cake and Am_2SO_4 in equal proportions. The exact proportion and quantity of the mixture suited to different soils has got to be worked out and then applied.

Seed and Sowing

Cloves of garlic are obtained from bulbs specially selected for the purpose from the previous season's harvests. The quantity varies considerably. Six to eight maunds is the usual seed rate. In Bangalore and Kolar Districts higher seed rate, *i.e.*, 10-12 md. of bulbs, is used, particularly for the *hingar* crop. In Chikkaballapur and Devanahalli, they use 25-30 md. If 3 md. of bulbs are crushed, 2½ md. of cloves good enough for planting are obtained. The fields are splash-irrigated two days before planting and when it is in condition sowing is taken up. The cloves are sown by broadcast or in plough furrows. In the case of the latter, cloves are sown by hand in every alternate furrow. Cloves sown in one furrow get covered by the soil from the adjacent furrow. Sometimes shal-

low furrows are opened across the strips at 1' apart and cloves are sown thinly at 3-4" apart in these furrows and are then covered with a layer of manure or surface soil. Broadcasting in long strips is, however, the most common practice. After the cloves are broadcasted in those strips a light blade harrow or a light hand rake is drawn to fix them into the soil. The same thing is done by stirring the field with *Kaiguddaly* (hand hoe). Then a levelling board to press the soil over and round the cloves is worked and at the same time any clove that may be lying exposed is pressed into the soil by fingers. On clay soils the beds are even trampled to press the cloves into the soil. The fields are then flooded.

No work has so far been done in this country in regard to fixing the optimum spacing and size of the cloves, method of planting, etc. Cultivators adopt close planting and big-sized cloves. Work done in this connection in some of the American States show that closer the planting the better it is. According to them 4" × 6" is better than 6" × 6" or 9" × 6". Bigger sized cloves from the outer portions of the bulb give better yield than small-sized cloves from the inner portion of the bulbs. Cloves are better planted horizontally than vertically. In a few cases as in Kadur, Hassan and Tumkur they use sprouted cloves. Those sprouted cloves are dibbled into the furrows or beds which ae irrigated previously.

Cloves take about a fortnight's time to germinate and appear above ground. After they germinate the crop is irrigated once in 5 days on sandy soils and 10-15 days on clay soils till about a fortnight before the crop is harvested. When germination is complete, *i.e.*, about a month after sowing or planting thinning and filling up gaps are done to get a uniform stand of the crop. The crop is weeded twice or thrice with an implement called *Dasi*. The crop matures in 14-16 weeks' time according to variety and time of planting. The *mungar* crop is ready for harvest by the middle of August and the *hingar* crop by the middle of March when they are pulled out or dug out. After drying them in the field for a day or so they are taken into the drying floor near dwelling quarters for further drying and handling. The yield of the crop is about 10 times the seed rate. Where they take two crops in the same years on the same land, the first crop may even yield 12 times the seed rate or even more while the second yields hardly 6 or 8 times, as it does not receive so much manure.

Preparation of the Crop for the Market

After harvesting and preliminary drying, the roots and all loose sheaths are removed and the bulbs are cleaned. They are then tied into small bundles and dried for 1 or 2 months in shade. Their tops are removed and then sold in local markets or shandies. Sometimes, the semi-dry plants are plaited into long strings by braiding the tops and hung on to a pole or bamboo close to the ceiling of one's house where they remain for 2 or 3 months or till they dry. They are then lowered; the roots and tops are removed and clean garlic bulbs are carted to the nearest market after rough grading, *viz.*, small (marble size), medium and big (lemon size). In parts of Hassan and Kadur it is also the practice to sell away the standing crop as *Hasurvani* or *Pacha maru.*

Trade

Production of garlic in Mysore is varying from year to year. A rough estimate would be about 7,000 tons per annum. The produce retained is about 25 per cent. for their own use either for consumption as an article of food or for seed purposes or for barter. According to the report on the subject by the Mysore Marketing Department, about 12·7 per cent. is retained for domestic consumption, about 8 per cent. for seed purposes and about 2·7 per cent. for barter, the balance is available for trade. There is not much inter-state trade in garlic. The quantity exported from the State is about 609 Rly. md. and the quantity imported into the State is about 1,233 Ry. md. There is however much inter-district trade. The producing centres are mainly Chikkaballapur, Sidlaghatta, Arsikere, Hassan, Chamrajanagar, Kadur and Chikmagalur, while the consuming centres are the cities of Bangalore, Mysore, K.G.F. and all the District Headquarters and other important towns.

Commodity moves from the producing centres to the consuming centres by rail, carts and lorries. About 70-80 per cent. is moved by carts and the rest by rail or lorries. Cart hire is charged at 2 annas per mile per maund. Lorry hire is 4-6 annas per mile per maund and railway frieght is 1-2 annas per local maund.

Producers generally take their crop to the *Shandy* or the nearest market in carts or on headloads or gunny bags or baskets. Unit of purchase of garlic differs from place to place. It is by weight, *i.e.*, in maunds in Bangalore, Hosakote, Chikkaballapur, Kadur, Kolar, Tumkur, etc. In Periyapatna, Hunsur, Arsikere, Krishnarajpet and Hassan, it is by measure. The

maund in Bangalore is 28 lb., in Hosakote it is 24 lb. and in Chikkaballapur it is 24 lb. In regard to unit of sale by measure it is 100 measuring seers standardised by Mysore Government. Sixteen measuring seers will weigh about 1 local maund of 24 lb. In regard to retail sale it is ¼ seer whether by weight or by measure in places mentioned above.

Prices

Prices normally fluctuate with the season and the quantity produced but there has been a very steep rise and fall in regard to the price of this commodity during the last 10 or 15 years. Sudden rise in prices of garlic during 1941-42 to

1940–41	.. Rs. 5 to 6	1950–51	.. Rs. 6 to 7
1941–42	.. ,, 7 to 8	1951–52	.. ,, 5 to 6
1942–43	.. ,, 16 to 17	1952–53	.. ,, 5 to 6
1943–44	.. ,, 16 to 17	1953–54	..
1944–45	.. ,, 16 to 17		
1945–46	.. ,, 16 to 17		

1945-46 is entirely due to war. These years synchronise with maximum acreage and production too. After the war, prices have returned to normal as they have in regard to several other commodities. The retail price of garlic is Re. 1 per maund more than the wholesale price. Abundant stocks of garlic are seen in the market during August, September, October and November for summer crop, and February, March, April and May for winter crop. Months of poor supply will be January, June and July. These are off-season for garlic.

The entire quantity available for trade is used for household purposes. Little or no use is found for industrial purposes. *Ayurvedic* and *Unani* doctors use small quantities for medicinal purposes. The quantity actually consumed by them cannot be easily ascertained. The demand for home consumption is more when fresh crop comes to the market.

Uses

Garlic is largely used for spicing or flavouring. It is used as a preservative. It is also of great medicinal value. It is an important specific for all diseases resulting from child birth and also for healing intestinal ulcers. It has digestive, carminative and anti-rheumatic properties. Garlic is also a specific for muscular pains and giddiness. It is a specific for sore eyes too. It is thus an important home medicine. The peculiar odour is due to the presence of a volatile oil. According to certain authors, garlic contains 21·93 per cent. of fructose (dry weight). Its vitamin C content is high.

Pests and Diseases

There are very few pests and diseases attacking garlic. The thrips (*Thrips tabacii*) which attack onion also attack garlic and cause serious damage. They lacerate and puncture the leaves sucking the sap and weakening the plant. Remedy lies in dusting with tobacco dust or spraying with tobacco decoction. Among the diseases Mildew (*Odidopis taurica* Salm. and *Erysiphe taurica* Lev.) which attack chillies and brinjals also attacks garlic. Bordeaux mixture spraying will however prevent the fungus spreading to healthy plants.

Another disease of some importance is *Alternaria palundi*; spraying with Bordeaux mixture will prevent the spread of the disease.

Thus in brief is an account of garlic crop in Mysore. Garlic is also a paying crop. The following figures representing the cost of cultivation and returns will indicate an account of profit the growers can make with this short duration crop.

Operations	Pairs	Men	Women	Boys	Cost
					Rs. A. P.
Ploughing three times ..	4	4	..	..	8 8 0
Passing cultivator three times ..	1	1	..	..	2 2 0
Passing *halube* (spiked harrow) once ..	1	1	..	..	2 2 0
Manure at 20 cart loads per acre ..	..				40 0 0
Spreading manure ..	..	1	2	..	2 8 0
Seed : 8 Md. at Rs. 6 per Md. ..	..				48 0 0
Broadcating seed and working *halube* ..	½	4½	..	..	5 1 0
Opening water channels ; irrigation ..	..	4	..	..	4 0 0
Weeding and Mulching ..	..	12	20	..	15 0 0
Harvesting ..	..	..	..	..	7 8 0
Preparing the crop for the market at 4 annas per md. ; 150 Md.	..	..	..	..	37 8 0
Sundries ..	..	..	..	..	20 7 0
Total ..	6½	27½	22	..	192 12 0 or 200

Returns at Rs. 5 per Md. : 150 Md. ..	Rs.	750
Gross profit ..	,,	550
Less Marketting expenses at 8 annas a Md. ..	,,	75
Net profit per acre ..	,,	475

Thus a net profit of Rs. 475 or 500 within a period of 4 or 5 months is obtained from this crop. There are very few crops involving not much risk or outlay still yielding such a large margin of profit in such a short time as four months. Potato is another crop but it involves a lot of risks and investment.

—Received 4th July 1954.

EFFECT OF LIME AND PHOSPHATE ON YIELD AND POD FILLING OF GROUNDNUTS

By B. V. Venkata Rao* and Dr. S. V. Govindarajan*

In Mysore State groundnuts as an oilseed is fast superseding other long-established crops in this field such as gingelly (*Sesamum indicum*), Niger (*Guizotia abyssinica*) and others. The yield of oil per acre from groundnut is essentially a function of the yield of well-filled kernels and any work on groundnut manuring should necessarily aim at obtaining good kernel development or conversely to reduce the proportion of unfilled pods.

Groundnut, unlike most other crops, is not known to respond to nitrogenous manuring.[1] Even potash does not seem to be of any major significance.[2] But presence of an adequate supply of available calcium either naturally present in the soil or supplied through liming materials is known to be very essential for proper kernel development. Colwell and Brady[3] working with calcium deficient soils report significant increases in the quality of peanuts with applications of gypsum. Rogers[4] reports increase in shelling percentage of groundnuts with applications of lime. Greenwood[1] found direct responses to lime in the shape of both better kernel development and haulm production on some soils, and on others due to interaction of lime and phosphate.

Experimental

To ascertain the effect of lime and phosphate singly and in combination on the yield and kernel development, a field experiment on statistical lines was conducted at the Hebbal Farm during monsoon 1951 and 1952 and repeated in the following years. The Hebbal soil is an open texture red loam, low in organic matter, nitrogen, phosphorus and calcium, the last element occurring in the soil to the extent of only 0·2-0·3 per cent. soil. The reaction of the soil is nearly neutral. Lime was applied in the concerned treatments in the form of burnt and freshly slaked limestone and well worked into the soil a week prior to sowing of groundnut. Spanish variety groundnut was used in the experiments. After harvest, the nuts from the dif-

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ferent replications of each treatment were composited and samples were taken for laboratory investigations.

The same set of treatments were adopted on the fields of Ramkrishna Krishi Sala, Anekal Taluk, on a bulk scale where the soil conditions are similar and the yield of groundnut pods were obtained. These data are recorded in Tables I and II.

TABLE I

Treatment	Experiment during 1951 at Hebbal Farm				Expeirment during 1952 at Hebbal Farm			Experiment during 1952 at Ramakrishnapur
	Groundnut pods in lb. per acre	Shelling percentage	Ratio, Volume/ Weight	Calculated yields of kernels in lb. per acre	Groundnut pods in lb. /acre	Shelling percentage	Calculated yields of kernels in lb. per acre	Groundnut pods in seers per acre
1 Control ..	508	69·3	4·02	352	379	76·5	289	108
2 Lime at 100 lb. per acre	539	71·8	3·89	387	389	77·8	303	130
3 Lime at 100 lb. per acre + Superphosphate at 1 cwt. per acre	807	74·8	3·79	603	418	78·7	329	167
4 Superphosphate alone at 1 cwt. per acre	660	72·7	3·77	480	421	77·5	326	120

TABLE II. *Analytical data*

Treatment	Experiment during 1951 at Hebbal				Experiment during 1952 at Hebbal			
	% Moisture in the kernels	% oil	% Free fatty acid in the oil as mg. of KOH	Calculated yield of oil in lb./acre	% Moisture in the kernels	% Oil	% Free fatty acid in the oil as mg. of KOH	Calculated yield of oil in lb. per acre
1 Control ..	6·26	48·59	523	171·2	3·45	48·05	117	138·9
2 Lime at 100 lb./acre	6·13	47·30	438	183·1	3·30	48·71	168	147·6
3 Lime at 100 lb. + Super, at 1 cwt./acre	6·27	48·23	490	293·0	3·32	48·92	80	161·0
4 Super, at 1 cwt./acre	6·19	47·45	463	227·6	3·66	48·54	105	158·2

Discussion

From the data it is seen that lime and phosphate in combination have given the highest yield (Table I) and the effects are significant (C.D. of 123·5 lb. per acre) for the Hebbal experiments. The main effect of phosphate is also found to be significant in the experiment during 1951. In the experiment during 1952, the yield was poor on account of severe drought conditions and the increases are not significant. The results of the experiment at R. K. Sala are in line with the other two experiments. The figures for shelling percentage, volume to weight ratio and calculated yield of kernels per acre (Table I) definitely indicate an increase in the production of kernels. The increase in yield of pods (by weight) is in the main due to the increase in weight on account of better filling of pods than due to increase in number of pods formed. Though there are no differences in the percentage of oil in the nuts from the different treatments (Table II), oil production from an acre is appreciably higher in the treatments where lime and phosphate are applied together than either in the control or in the treatments where they are supplied separately. There is tendency for the decrease in the free fatty acid content in all the three treatments over control which is also an indication of better maturity of seed at the time of harvest.

Summary

The yield of oil from groundnut per acre is mainly a function of pounds of plump kernels produced. Calcium is known to beneficially influence the formation of kernels. In this paper the results of two statistically laid out field experiments and one bulk experiment to study the influence of lime and phosphate together and each of them separately on yield and kernel development are reported. Lime and phosphate in conjunction and phosphate alone to a certain extent is found to significantly increase the yield of groundnut pods. The increase in yield of groundnut pods is seen to be due to better kernel development as indicated by volume to weight ratio and shelling percentage. The oil produced per acre is the highest with lime and phosphate applied together.

References

1. Greenwood, M. (1951), *Emp. J. Expt. Agric.*, 19 (76), 225-40.
2. Brady, N. C. and Collwell, W. E. (1945), *J. Amer. Soc. Agron.*, 37 (6), 429-42.
3. Collwell, W. E. and Brady, N. C. (1945), *Ibid.*, 37 (6), 413-28.
4. Rogers, H. T. (1948), *Ibid.*, 40 (1), 1-44.

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TWO DISTINCT SPECIES OF *EPILACHNA* (COLEOPTERA: COCCINELLIDAE) FEEDING ON SOLANACEOUS AND CUCURBITACEOUS PLANTS

By Dr. G. P. Channa Basavanna*

Introduction

Lefroy (1909), Fletcher (1914), Subramaniam (1924), Krishnamurti (1932), and others have reported *Epilachna vigintioctopunctata* (Fabr.) as a very common species of *Epilachna,* found feeding on solanaceous and cucurbitaceous plants in various parts of India. During June 1954, *Epilachna* beetles, superficially resembling the above species, were collected from bitter gourd (a cucurbitaceous plant), and when enclosed on potato leaves in the laboratory in an attempt to rear them on this host, it was noticed that they did not feed on potato leaves. This led to further studies on the feeding habits and certain morphological characters of *Epilachna* beetles (having apparent resemblance) feeding on solanaceous and cucurbitaceous plants, with a view to establish whether only one species is concerned, or more than one, and whether these beetles exhibit any specificity with regard to the choice of hosts. This is particularly significant in view of the fact that *Epilachna* beetles are often serious pests of many solanaceous and curcubitaceous vegetable crops.

Feeding Habits

Epilachna beetles superficially resembling *E. vigintioctopunctata* were collected from different solanaceous plants, like potato, brinjal, *Datura, Solanum nigrum* and *S. xanthocorpum,* and cucurbitaceous plants, like bitter gourd (*Momordica Charantia*) and *Momordica dioca,* and beetles from each host were enclosed in batches separately in jars on leaves of different solanaceous and cucurbitaceous plants apart from the natural host plant. Each batch was continued for a period of 2 weeks or less, if all the beetles in the batch died earlier. In each case leaves of the host plant kept dipped in water contained in small

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vials were provided and leaves changed daily. The observations made with regard to the feeding habits of each batch of beetles are summarised in Table I.

TABLE I

Feeding tests with Epilachna *beetles found feeding in nature on different solanaceous and cucurbitaceous plants*

Plants provided in laboratory \ Natural hosts	*Momordica Charantia* (bitter gourd)	*Momordica dioca*	*Solanum tuberosum* (Potato)	*Solanum melongena* (brinjal)	*Datura stramonium* (Datura)
M. Charantia (bitter gourd)	++	++	–	–	–
Trichosanthes Anguina (snake gourd)	–	–	–	–	–
Cucurbita maxima (pumpkin)	–	–	–	–	–
Lagenaria vulgaris (bottle gourd)	–	–	–	–	–
Luffa acutangula (ridge gourd)	–	–	–	–	–
Sechium edule	–	–	–	–	–
Luffa ægyptica	+	+	–	–	–
Coccinia indica	–	–	–	–	–
Cucumis sativus (cucumber)	–	–	–	–	–
Momardica dioca	++	++	–	–	–
S. melongena (brinjal)	–	–	++	++	++
Datura stramonium	–	–	++	++	++
Lycopersicun esculentum (tomato)	–	–	++	++	++
S. tuberosum (potato)	–	–	++	++	++
S. nigrum ('Kachi')	–	–	++	++	++

++ fed well; + slight feeding; – no feeding.

It is seen that beetles collected from bitter gourd and another allied species (*M. dioca*), have fed only on bitter gourd and *M. dioca* quite well and very sparingly on a few other cucurbitaceous plants, like *Luffa ægyptica*, and not at all on any of the solanaceous plants. The beetles collected on any of the solanaceous plants mentioned above have each exhibited the same feeding behaviour in that beetles from any one of the solanaceous host plant could feed on any other solanaceous plant, and not in any case on a cucurbitaceous plant. Attempts made to induce the larvæ emerged from eggs laid by bitter gourd *Epilachna* beetles to feed on solanaceous plants, and similar larvæ from solanaceous material to feed on bitter gourd leaves failed, and the larvæ soon died in each case. Leaves of unacceptable host plant coated with the juice of an acceptable host plant, when provided to beetles got from the acceptable host plant also failed to evoke any sufficient response and only a slight nibbling was seen in a few cases. Hence there are two groups of *Epilachna*, each exhibiting distinct specificity in its selection of host plants, the one solanaceous plants alone and the other only bitter gourd and another allied species of gourd.

Morphological Characters

(*a*) *Spots on the Adult*

Lefroy (1909) and Fletcher (1914) have figured the adult beetle showing 28 dark roundish spots on the dorsal surface. Krishnamurti (1932) has shown 36 spots on the dorsal surface of the beetle, though he has stated that 'the presence of 28 dark roundish patches on the dorsal surface renders the identity of the beetle extremely easy'. Lefroy (1909) has clearly stated that there is great variation in the general colour of the dorsal surface and in the number of spots on the body of the beetle. The typical number, distribution and arrangement of dark spots on the dorsal surface of the beetle, and the representative variations in the number of spots in both groups of beetles are shown in Fig. 1. The present observations confirm Lefroy's statement in that the colour of the dorsal surface varies from pale yellow to almost dark reddish brown. The roundish dark spots on the dorsal surface are arranged in a definite way as shown in Fig. 1, J and K, and their number varies from 12 to 28 on the elytra and nil to 6 on the pronotum. The variation in general colour, and the size and number of spots is more evident in the material from solanaceous plants

rather than in the beetles from bitter gourd, so much so in the latter group beetles with less than 18 spots on the elytra and two on the pronotum were not noticed and the dorsal surface was usually dark brown. In any collection of beetles, the proportion of beetles having different number of spots usually shows a decrease from 28-spotted to 12-spotted beetles, the 28-spotted ones being most common in a collection. It is also seen that disappearance of the spots on the elytra of beetles having lesser number of spots than the typical (28) more or less follows a definite plan and only spots Nos. 14, 11, 13, 7, 2, 9, 6 and 4 tend to disappear, and the other spots (Nos. 1, 3, 5, 8, 10 and 12) have not been observed to disappear in any specimen and are stable, and thus in the 12-spotted beetles (Fig. 1, *i*) it is only these six numbers that are retained. In rear cases, it is noticed that 2 adjacent spots (*e.g.*, Nos. 8 and 10) both on the elytra and pronotum (*e.g.*, Nos. 2 and 3) fuse and form a continuous irregular dark patch.

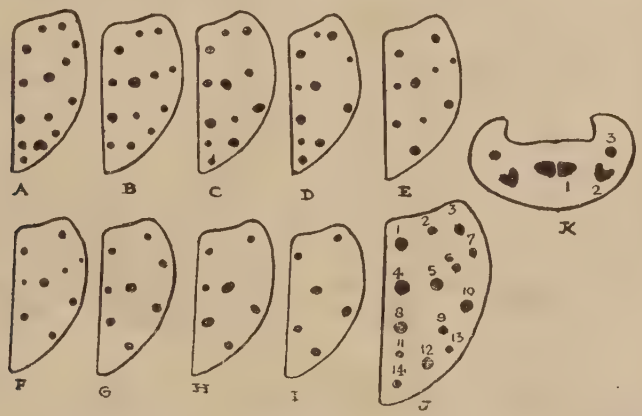

FIG. 1. Diagrams of elytra and pronotum of *Epilachna vigintioctopunctata* and *Epilachna* sp. A–I, representative variations in number of spots ; J, typical number of spots numbered ; K, pronotum with typical number of spots numbered.

(*b*) *Other Characters in Adult*

(*i*) *Tip of the Abdomen.*—There is no marked difference in the abdominal tip of the male between the two groups of beetles.

(*ii*) *Male Genitalia.*—The male genitalia of both groups is shown in Fig. 2. It is seen that apart from other differences in size and shape of the different structures, the distal tip of the penis in beetles from bitter gourd and *Momordica dioca* is more bent than that in beetles from solanaceous plants, and the distal tip of the hypo is also quite different in shape from that seen in beetles from solanaceous plants.

(c) Larval Characters

Fourth instar larvæ in both groups were examined. It is found that the larva from the bitter gourd is generally bigger than the larva of the same age from potato or other solanaceous plants. The former appears more yellowish because the dark brown areas around the scoli are not so pronounced as on the larva from a solanaceous host. The fourth instar larva from a solanaceous host comes very close to the description of the larva (fourth instar) of *E. vigintioctopunctata* given by Kapur (1950), with a few minor differences. A comparative detailed description of this and that from bitter gourd will be given in another paper.

FIG. 2. Male genitalia : Paramera and penis, etc. (a), hypo (b) and tip of hypo (c) of *E. vigintioctopunctata*. Paramera and penis, etc. (d) hypo (e) and tip of hypo (f) of *Epilachna* sp.

Summary and Conclusions

Occurrence and similar variation in colour patterns in the two groups of *Epilachna* beetles feeding on solanaceous and cucurbitaceous plants and as such their superficial resemblance has perhaps led many of the previous workers to believe that *Epilachna vigintioctopunctata* is the species concerned in the infestation of both the groups of plants alike. The above observations with regard to feeding tests and differences in the male genitalia definitely prove that (1) two species are involved, one feeding on solanaceous plants in general and has been identified as *E. vigintioctopunctata* (Fabr.) and the other on

bitter gourd and *Momordica dioca* and very sparingly on a few other cucurbitaceous plants and has been put as *Epilachna* sp. for the present ; and (2) the two species exhibit definite specificity in regard to the choice of their hosts, the one confined to solanaceous plants only and not taking to cucurbitaceous plants, and the other only to bitter gourd and a few other cucurbitaceous plants and never feeding on solanaceous plants.

Acknowledgments

The author wishes to express his gratitude to Dr. M. Puttarudriah, Government Entomologist, for his keen interest and for facilities provided. He is thankful to Dr. A. P. Kapur, Zoological Survey, Calcutta, who kindly determined the species of *Epilachna,* and to Sri. P. R. Raghuram, Artist of the Department, for his kind help in making the drawings.

References

Fletcher, T. B. (1914), *Some South Indian Insects* (Govt. Press, Madras), 292.

Kapur, A. P. (1950), "The Biology and External Morphology of the Larvæ of Epilachninæ (Coleoptera : Coccinellidæ)", *Bull. ent. Res.* 41 (1), 161-208.

Krishnamurti, B. (1932), "The Potato *Epilachna* Beetle, *Epilachna vigintioctopunctata* (Fabr.)", *Bull. Dep. Agric., Mysore, Ent. Ser.,* No. 9.

Lefroy, H. M. (1909), *Indian Insect Life* (Thacker, Spink & Co., Calcutta), 308-09.

Subramaniam, T. V. (1924), "Some Coccinellidæ of South India", *Rep. Proc. Fifth Ent. Meeting,* Pusa: 108-18.

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PROSOPIS JULIFLORA AS LIVE FENCE

By K. Venkoba Rao, B.Sc. (Ag.)*

Prosopis juliflora, popularly known as "Mesquite", is a native of Brazil† and belongs to Leguminous family. The plant, not relished by goat and cattle and growing quick with pruning at regular intervals, forms a good and compact live fence. The plant has drought-resisting character which is an advantage to get the benefit of a good live fence even in scanty rainfall areas.

The trees grow to a height of 20-25′ with profuse long flexible branches with abundant foliage. There are thorns on all branches closely placed and are seen at every leaf-axil. The thorns also emerge in pairs. The plants when they are of 3-4′ can be pruned and brought to any shape and size. Due to pruning of the growing branches, side shoots emerge from bottom portions of the trunk, giving a thick and lusty growth so as to prevent the trespass of men and animals. When the tree is left to grow itself to nature, it produces very long branches on all sides and when a number of trees are grown closer, the branches of each other get twisted and form a thick fence like a fort wall. The advantage of these long branches and the easy way to intertwist them, with other branches is also very helpful for growing them as windbreaks.

The lands on the Hagari river bank (Bellary District) were constantly subjected to sand drift due to heavy winds and the lands were becoming unfit for cultivation, due to deposition of large quantities of sand. Thanks to *Prosopis juliflora* which came to the rescue of the cultivators as windbreaks, it has prevented further drifting of sand from river bed. The then Madras Government got *Prosopis juliflora* plantation done on a large-scale all along the river course, and now the trees have fully grown to serve the purpose. The trees are also useful for fuel purpose. The villagers nearer the plantations express that the wood is excellently suited for making agricultural implements, specially the country plough.

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* Plant Protection Assistant, Bellary.

† See Editorial article.

The pods are yellow in colour and drop off from trees when fully ripe. The pods are made up of hardy fibrous material covering the seeds, which give considerable difficulty in extraction of seeds. The seeds when extracted have a very hard seed-coat and require pre-treatment before sowing. The ripe pods dropped to ground are much relished by cattle, due to the presence of syrupy juice in the pods. The pods are eaten as they are and due to the hard seed-coat the seeds are not digested but are thrown out in the dung. These seeds which pass through the animal system are seen to germinate more readily and easily. Generally the seeds are extracted after soaking pods in water from 24-36 hours and sun-dried the next day or two before pounding. In Bellary District the ripe pods are merely sun-dried and pounded by hand in a pestle and mortar, and seeds extracted. The seeds thus extracted have a hard seed-coat, and under dry condition they do not give a satisfactory percentage of germination. To get a good germination, the seeds may be soaked in water for 24 hours before sowing or the seeds may be mixed with sand at 1 : 3 proportions and pound with a pestle and mortar, so as to give a fine scarification of the seed-coat. The seeds can also be pre-treated by immersing seed in hot water at 75° C. for 2-3 minutes. While resorting to the last method, if the temperature of water is more or immersing seed for more than 3 minutes may result in damaging seeds and consequently poor germination. The seed rate required is about 1 oz. of seed for 100′ length. The seeds may also be sown in nursery and the seedlings transplanted when they are 1-1½ months old. The plants are deep rooted and grow quicker compared to other live fences.

The seeds may be sown at 2″ apart within the line and after their germination thinning may be done to the desired extent depending on the height to which the tree is to be allowed to grow. For example when this is to be grown as a live hedge of 3-4′ height, the seeds may be sown closer at 6-9″ apart, and pruned at fortnightly intervals. When the tree has to be grown as a live fence for a field, the seeds may be sown in double lines at 12-15″ apart in the line and 18″ in between lines. If the trees are to be grown as windbreaks the optimum spacing would be about 2-4′ between tree to tree. Unless the trees are grown as windbreaks, regular pruning is necessary in all other cases. The thorns drop off after one year, hence by regular pruning it should be seen that the tree puts forth fresh branches at the base and provide thin and sturdy thorns. The pruning should

be done at such intervals, so as to have fresh branches of less than an year old all along the fence to check the human and cattle trespass.

After a few years of stand of the fence there may be root effect on the cultivable land and to prevent any such effect a trench of 2′ may be dug by the side of the fence towards the inner side of the fence. Regarding the shade effect this may be avoided by regular cutting of the extra long branches. The trees are useful to be grown in waste lands and bare hillocks and arid afforestation. In the early stages of the plant growth it is necessary to see that the young seedlings are prevented from damage being caused by stray cattle and animals.

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SECRETARY'S PAGE

Dasara Exhibition.—The Union contributed its exhibits to the Agricultural Stall at the Dasara Exhibition at Mysore as usual ; and one of the exhibits was a large-sized map of Mysore State indicating membership of the Union to-date. Figures are given below :

	District	No. of life-members	Rs. 3–4–0 members	As. 0–4–0 members
1	Bangalore ..	133	1,135	1,856
2	Mysore ..	108	449	1,450
3	Shimoga ..	61	277	2,310
4	Mandya ..	49	677	2,502
5	Chitaldrug ..	37	396	2,007
6	Bellary ..	32	303	269
7	Hassan ..	27	343	1,556
8	Kolar ..	20	596	883
9	Tumkur ..	15	164	1,549
10	Chikmagalur ..	9	141	156
	Total ..	491 (both full paid and part paid)	4,481	14,538

Among other things exhibited were photos of *Student Farmers' Clubs* and *Field-days* and *publications* of the Union. These represented the three activities of the Union.

A film on Field-Day and Student Farmers was also shown at the Exhibition grounds.

Student Farmers' Clubs.—These have been formed in numbers with village boys around the Mandya Training Centre and in the National Extension Blocks. Outside of the Project areas also they have been sponsored at several schools.

A second rally of the Student Farmers was held recently at the Training Centre, V. C. Farm, Mandya.

A rolling Shield has been kindly donated by Sri. K. H. Srinivasan, M.A., B.Sc. (Edin.), Retired Director of Agriculture in Mysore, to be given each year to the winning Student Farmers' Club, clubs from all over the Mysore State being eligible to compete on satisfying the required conditions. These conditions in outline are as follows :

"The club must be one which has registered itself with the Mysore Agricultural and Experimental Union. It may be one

organised in a school, in a village, or in a part of a town like a street or extension. It may be a boys' club or a girls' club. It must have a Leader and may have five to fifteen members of between 8 and 21 years of age.

Each competing club will pay a fee of Re. 1-0-0 to the Union Centre.

If there are more than 10 competing clubs in a Taluk or a group of villages, the Agricultural Inspector or the village level worker may judge the clubs and indicate the best of the group to be judged by the District or Project Agricultural Officer. The best one or two of the clubs from districts and project areas may be judged by the Secretary and representatives of the Union Centre. Clubs may inform the Union Centre as also the local Agricultural Officers, when their crops are at their best and see that the crops will be noted.

The clubs will be judged both for their individual and their group projects.

(*a*) The higher the percentage of student members who have earned the pink badges of the Union, the greater the score the club will have. There are three kinds of badges, one kind to be given to a student on enrolling in the club, one kind to be earned by him after growing a crop or finishing a project and the third kind, *i.e.*, the pink, to be secured by the student on his growing a crop or finishing a project and also putting up scientific notes on the project allotted to him.

(*b*) Group activity will be judged with reference to two points: (1) acreage of crops grown or handled, trees planted, variety of projects, and similar scorings; and (2) organisational and social activities, meetings conducted, group songs recited, etc.

Other prizes besides the Shield may be awarded according to circumstances."

Meanwhile a form in which a report of each club may be sent to the Union Centre has already been circulated to the District Officers.

It is as follows:

FORM OF REPORT

1. Place and address of the Student Farmers' Club.
2. Name of the Club, if any:

(*a*) By any special name, if adopted,

(*b*) By project undertaken.

3. Leader of the Club—Qualifications and background.

4. Number of students in the Club.
Names of students—age—class.

5. Types of activities undertaken.

6. Any assistance given by the local people by way of finance, plots of land, etc.

7. Whether students have been given the initial badges of the Mysore Agricultural and Experimental Union.

8. Achievements, individual and group :

(*a*) Number of students securing Union Second Badges ;

(*b*) Number of students securing Union Third Badges.

(*c*) Work accomplished like number of trees planted, manufactured, prizes won, etc.

9. Any other information.

One other line of work of the Union since last year has been to get the members of the Union interested in *crop competitions*. The following are the current rules for *Dryland Ragi* competition, for which a few prizes are offered by the Union.

Rules for Dryland Ragi Competition

The competitions will be open to all competitors who pay a competition fee of Re. 0-8-0. Payment may be made to the local Agricultural Inspector or the Assistant Director of Agriculture of the District, but the competitors will be enlisted on receipt of the fees at the Head Office of the Union, Bangalore.

Each competitor will offer half-an acre of dryland ragi for competition.

He will give an undertaking in the following form to the Assistant Director of Agriculture of his District :

'I..... son of ..... desire to offer ½ acre of dryland ragi, in survey number..... of the village..... Taluk..... District.....for competition. I agree to inform the Assistant Director of Agriculture.....or the Agricultural Inspector.....,on his behalf, 20

days before the intended harvest date, and also to help the appointed persons to take sample cutting.'

The Assistant Director of Agriculture in consultation with the District, Taluk or Hobli Committees of his circle will arrange, as he thinks best, to take the sample cuttings and declare the yields. His judgment will be taken as final.

The highest yield of each district will be given a prize of Rs. 50 by the Union Centre.

The District, Taluk and Hobli Committees of the Union may allot other prizes from their branch funds to winners in their jurisdiction.

M. VASUDEVAMURTHY.

Correspondence

USE OF WELL BALANCED MIXED FERTILISER FOR POTATO CROP

On January 1, 1954, I planted 90 md. (local) Simla seed potatoes in my lands—about 2¼ acres—at Bendigenahalli. I had given the land a basal dressing with 70 cartloads of farmyard manure and applied in the furrows at the time of planting 16 cwt. of Parry's Standard Potato Fertiliser, analysing 4·5 per cent. nitrogen, 15 per cent. phosphoric acid and 7 per cent. potash. At the time of earthing up I gave a top-dressing with the same Parry's Standard Potato Fertiliser weighing 2 cwt. at such portions where the plants had not come up nicely. The crop was harvested on 30th and 31st March 1954 and the harvest was stored in heap in the field until July 8, 1954 when it was removed to Madras for sale.

It is my firm belief gained by experience that use of chemical fertilisers in the form of well balanced, scientifically prepared mixtures by reliable firms like Parry & Co., Ltd., along with a good basal dressing of farmyard manure will not only produce a quantitative crop, but also one of good size, quality and of a very good retentive capacity as will be seen from my harvest which weighed 1158 md. (local) on the day of sale, *i.e.*, 3 months and 8 days after harvest. Only 16 md. of "Dok" partly deteriorated ones were removed at the place of sales in Madras in spite of the distant transport. During the re-doing of the heap while in storage on field for the said 99 days "Kolathohidu"—total deteriorations removed were only 20 md. or below 1·75 per cent. compared to such high wastages ranging from 10 to 30 per cent. suffered by my neighbours who had not applied the same fertiliser.

Kindly publish this bit of my experience on the manuring of potato crop in the Kannada and English organs of our Union for the benefit of my brother farmers interested in potato cultivation.

Hoskote,
September 20, 1954.

B. Channa Byre Gowda,
Ex-Vice-President,
District Board, Bangalore District.

OBSERVATIONS ON THE DURATION OF TIME TAKEN BY CROP PLANTS FROM FLOWERING TO MATURITY

SUBSEQUENT to my note on the observations regarding the duration of time taken by crop plants from flowering to maturity which appeared in the correspondence column of this journal (Vol. 30, No. 1), January-March 1954, I set forth below a series of further observations on the perennial cotton plants made in the month of December 1953 extended up to April 1954.

Date of flowering	Date of the boll beginning to dehisce	Date of picking cotton	Duration days	Remarks
21-12-1953	27-2-1954	1-3-1954	70	
24-12-1953	1-3-1954	3-3-1954	69	
25-12-1953	3-3-1954	5-3-1954	70	
26-12-1953	26-2-1954	27-2-1954	62	
28-12-1953	3-3-1954	4-3-1954	66	
29-12-1953	3-3-1954	4-3-1954	65	
30-12-1953	3-3-1954	4-3-1954	64	
1—1-1954	11-3-1954	14-3-1954	72	
16—1-1954		12-3-1954	55	*Gossypium acuminatum*
18—1-1954	20-3-1954	22-3-1954	63	*Gossypium peruvianum*
16—1-1954	21-3-1954	23-3-1954	66	do
20—1-1954	23-3-1954	24-3-1954	62	do
do	23-3-1954	25-3-1954	64	do
22—1-1954	25-3-1954	26-3-1954	63	do
do		25-3-1954	62	do
25—1-1954	22-3-1954	23-3-1954	57	do
2—2-1954	25-3-1954	26-3-1954	52	*Gossypium acuminatum*
5—3-1954	26-4-1954	27-4-1954	53	
do		do	53	
do	27-4-1954		54	
do	28-4-1954	29-4-1954	55	
11—3-1954		14-4-1954	34	*Gossypium acuminatum* Defective dehiscence
3—4-1954	1-6-1954	4-6-1954	59	
4—4-1954	28-5-1954	30-5-1954	56	

From the foregoing statement it is seen that the maximum time taken for dehiscence by the Peruvian cotton plant was 72 days and the minimum was only 53 days in this season. Further the indications are that *Gossypium acuminatum* (without the petal spot) take a smaller time for dehiscence than *Gossypium peruvianum* being only 52 and 55 days in two instances prominently noticed.

Bangalore,
October 12, 1954.

D. VENKATARAMANIAH.

MY IMPRESSIONS OF MYSORE*

I WAS selected to come to India on the International Farm Youth Exchange Program which is sponsored by the National 4-H Club Foundation. I arrived in India in the first week of September and was fortunate in getting to stay for 6 weeks in "The Garden Spot of India".

I arrived to my first host, Sri. Hombe Gowda, on September 12th and proceeded to his farm near Hunsur. It had not rained for quite a long time and he was hoping for rain. His wishing and hoping for rain reminded me of just three months earlier when we had the same situation in our farm in the U.S.A.

After two weeks with my first host, I travelled to Garageshwari with Mr. Abdul Gani and then to the village of Kodagahalli to stay with Mr. Javare Gowda. While with my hosts, I visited the Dasara Exhibition in Mysore and saw the beautiful procession. After leaving my last host in Mysore, I travelled back to Hunsur to again re-visit Sri. Hombe Gowda and his farm. When I visited, it had been raining for nearly a week and he commented that if it kept raining it would ruin his tobacco crop. With his comment of drought and excess, I fully realised that the problems of the farmers are the same all over the world and only differ in the intensity of the problem.

While with my hosts, I received very good food and all I could eat. My only trouble was in getting accustomed to the different foods. After several weeks, I came to like the food and now I enjoy it very much.

The hospitality in India has been the best. While at the Dasara celebration, I met many people whom I had met in the villages. They would come up, shake hands and we would chat for a while. When you are very far from home there is nothing more enjoyable than to have friends greet you and make you feel at home.

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* Sri. H. Hombe Gowda of Katte Malalwadi has given his impressions of U.S.A. in an earlier number of this Journal. He visited U.S.A. as an International Farm Youth Exchangee last year. Mr. Alderfer who came from Indiana stayed with some Mysore farmers and he has left with us his impressions of Mysore which we gladly reproduce here.—*Ed.*

I have visited many places in Mysore and marvelled at their beauty. The old temples, the beautiful gardens and the beauties of nature are all spectacular. I have also bought some of the beautiful works of art while in Mysore and wish that I could take many more articles with me. I have said many times that I wish I could take some of the beauty of Mysore back to Indiana with me, especially the weather.

I only hope that I have helped the program by winning friends for world peace. I know that I can now better understand the problems and people of India.

MONTE W. ALDERFER,

Bangalore. *International Farm Youth Exchangee.*

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